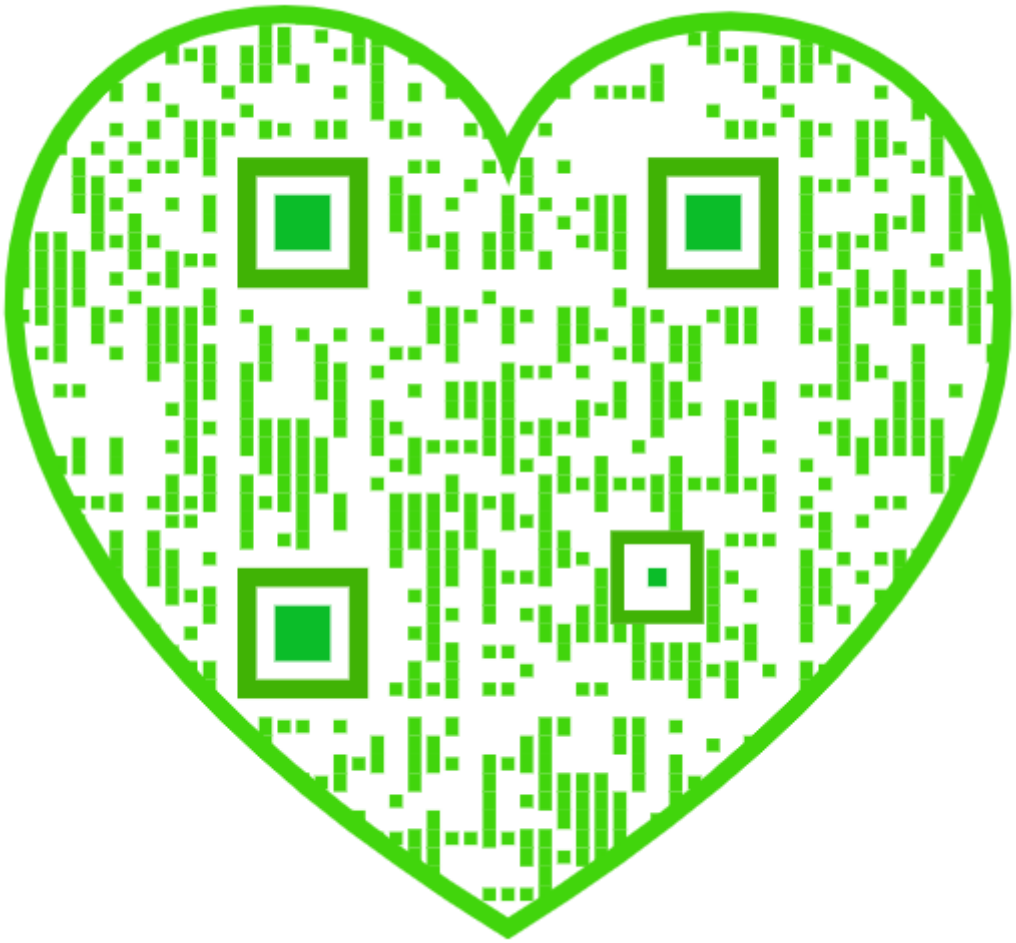

POTATO PESTS.

BEING AN ILLUSTRATED ACCOUNT OF THE

COLORADO POTATO-BEETLE

AND THE OTHER

Insect Foes of the Potato in North-America.

WITH SUGGESTIONS FOR THEIR REPRESSION AND METHODS FOR THEIR DESTRUCTION.

BY

CHARLES V. RILEY, M.A., Ph.D.,

(STATE ENTOMOLOGIST OF MISSOURI.)

ILLUSTRATED.

NEW-YORK:

ORANGE JUDD COMPANY,

245 BROADWAY.

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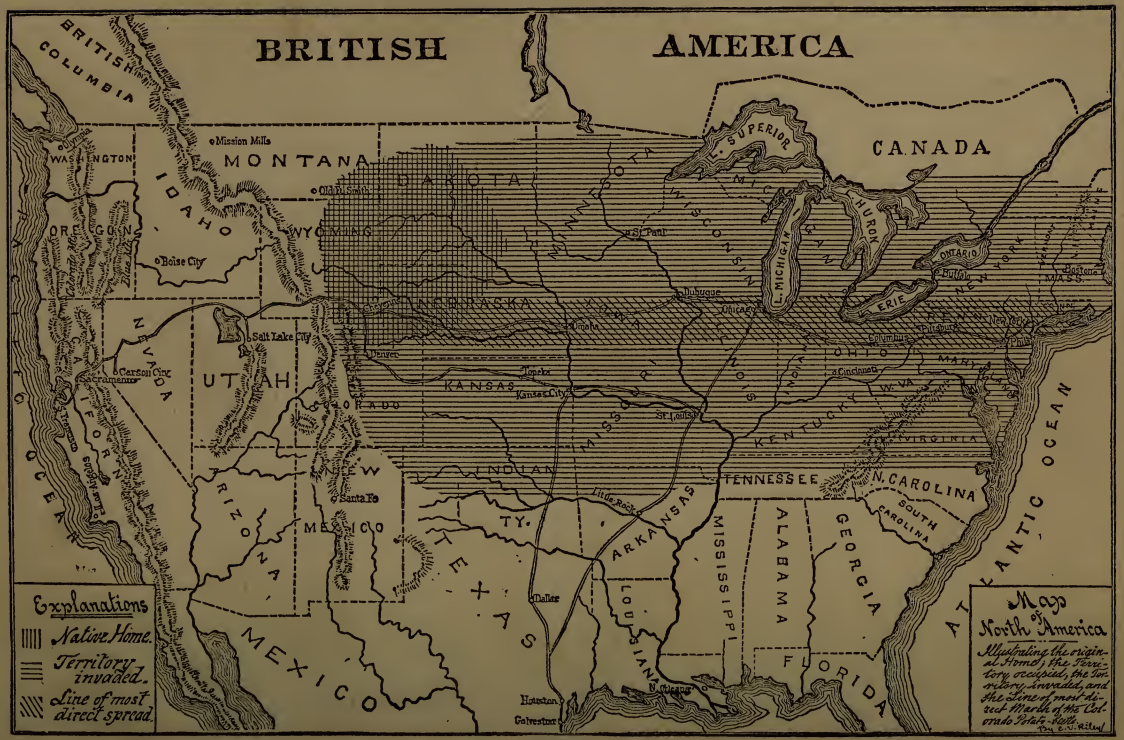
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Explanations
Native Home.
Territory invaded.
Line of most direct spread.
Map of North America
Illustrating the original Home, the Territory occupied, the Territory invaded, and the Line of most direct March of the Colorado Potato Beetle.

[Fig. 1.]

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PREFACE.

The Colorado Potato-beetle, to the consideration of which the following pages are principally devoted, continues to occupy a good deal of public attention; and now that its transportation to Europe has become a demonstrated possibility, demands from Europe for information regarding it are added to those that have been continually made by our own people as the insect has widened the area of its devastations. The editions of the earlier Entomological reports of Missouri have long since been exhausted, and the author has, to his regret, been unable to satisfy, of late years, the many applications for his writings on the subject. To this circumstance, and to the suggestion of the publishers that he should bring those writings together in some cheap, available form, with brief accounts of the other insects that injuriously affect the potato, this little volume owes its origin. The figures which illumine it, though they have, many of them, become familiar to the agricultural public by frequent reproduction in the columns of the industrial press, were most of them originally drawn from nature by the author, and for the text he can claim little more than that it is a compilation from his previous writings. With the explanation that some of the figures are enlarged, and have the natural size indicated only in hair-line; that the

term "larva," so frequently employed, means the second or worm-like state of an insect; that the term "pupa" means the third or dormant state, and that all statements rest either on his own experience, or on authorities cited in his reports; the author submits this little work in the hope that it may somewhere find a welcome, and to some one prove a source of profit.

C. V. RILEY.

St. Louis, Mo., November 1, 1876.

INTRODUCTION.

The Potato ranks deservedly high among the products of the farm. A luxury even to the rich, it yet forms the poor man's principal article of diet. Easily cultivated; yielding generously; thriving in most soils; requiring no process of manufacture to fit it for use—it is justly esteemed the most valuable of esculents. Whatever, therefore, injuriously affects it, excites general apprehension, and demands careful consideration.

The agencies which, at present, militate most seriously against successful potato-culture are fungus diseases, and noxious insects. It is with the latter that the following pages deal, and more particularly with the Colorado Potato-beetle, which is the most injurious and widespread of them.

Two interesting phenomena invariably accompany the settlement by civilized man of a country previously unoccupied by him: 1st, the exceptional increase and spread of the few indigenous species which exhibit exceptional powers of adaptation to the changed conditions that such settlement implies; 2nd, the more general increase and spread of European species, which have, through "natural selection" for centuries, most effectually conformed to those conditions, and which, by virtue of this greater adaptation crowd out the endemic forms. America, Australia, New Zealand, have been overrun by European imports, and are good illustrations in point. The increase and spread of one species necessitates the decrease—often to extermination—of another; and the adaptation of an endemic species to new conditions, as also the introduction and spread of a foreign one, imply and have often carried with them, modification in habit and character.

Within seventeen years there has been a grand revolution in the minds of thinking men as to the origin of things upon our earth. The idea of special creation of what we call "species," almost universally held prior to that time, has given way to that of the derivative origin of existing from pre-existing forms. Darwin has revolutionized our ideas, and given to the study of life, broader and deeper meaning than it had before; and there can be no better evidence of the change in public opinion, in this respect, or of the force of the doctrine of evolution, than the respect with which Huxley was recently listened to in New York, and the failure of opposers to weaken his arguments. The "survival of the fittest" aptly expresses one of the axioms of evolution, and among the most beautiful illustrations of it, and consequently, among the more tangible evidences of evolution which man, in present experience, can have; must be reckoned the visible changes that occur through his influence in the fauna and flora of a country—and particularly the two classes of phenomena just alluded to. It is, therefore, an interesting fact, that since 1859, the very year when the "Origin of Species" was first given to the world, America has afforded striking illustrations of both. In the Colorado Potato-beetle (*Doryphora* 10-*lineata*) we have a native species whose eastward spread has been carefully watched and recorded, from year to year; and in the Rape Butterfly (*Pieris rapæ*) an European species whose introduction and westward advance have been equally well observed since that time. Both have been found in these comparatively few years to undergo modification in habit and character. The history of the former thus acquires an interest to the naturalist, second only to that which, by virtue of its destructiveness, it possesses for the agriculturist.

THE COLORADO POTATO-BEETLE,

(*Doryphora* 10-*lineata*, Say.)

[Order, COLEOPTERA; Family, CHRYSOMELIDÆ.]

[Fig. 2.]

COLORADO POTATO-BEETLE:—*a*, *a*, eggs; *b*, *b*, *b*, larvæ in different stages of growth; *c*, pupa; *d*, *d*, beetle, back and side views—natural size; *e*, left wing-cover, showing punctation; *f*, leg—enlarged.

ITS PAST HISTORY.

This destructive insect commonly known as the Colorado Potato-bug, or simply as the Potato-bug* was first described under the scientific name of *Doryphora decemlineata*, in the year 1824 † by Thomas Say, who was then

* Entomologically the term "bug" is confined to a single Order of insects—the *Hemiptera*—and it is most correct and less misleading to say "potato-beetle." America is the only English speaking country in which all insects, indiscriminately, are popularly denominated "bugs," and with the spread of entomological knowledge, the custom will doubtless become obsolete.

† *Journal of the Academy of Natural Sciences of Philadelphia, Vol. III.*

acting as naturalist to Long's exploring expedition to the Rocky Mountains. The specimens from which his description was made had been collected in the region of the Upper Missouri, and it was at that time not uncommon there. The original food-plant of the beetle was subsequently found to be the Sand-bur (*Solanum rostratum*, Dunal), a species of wild potato peculiar to the region of the Rocky Mountains.

As civilization advanced westward, and potatoes began to be grown in its native home, this insect gradually acquired the habit of feeding upon the cultivated potato; and in 1859, it had spread eastward and reached a point one hundred miles to the west of Omaha city, in Nebraska. In 1861, it invaded Iowa, gradually, in the next three or four years, spreading eastward over that State. In 1864 and 1865, it crossed the Mississippi, invading Illinois on the western borders of that State, from the eastern borders of North Missouri and Iowa, upon at least five points on a line of two hundred miles. The first published account of the destructive propensities of the species may be found in the *Prairie Farmer* for August 29th, 1861, in a letter from Mr. J. Egerton of Gravity, Iowa, who stated that "they made their appearance upon the vines as they were up, devouring them as fast as they grew." From that time forth frequent reports of the species' great destructiveness west of the Mississippi appeared in most of the Agricultural papers. In October 1865, Benjamin D. Walsh of Illinois furnished to the *Practical Entomologist* an extended description of the new invader from the West, together with an account of its habits so far as they had been investigated; and in the same article expressed the conviction that in all probability it would in future years "travel onwards to the Atlantic, establishing a permanent colony wherever it goes, and pushing eastward at the rate of about fifty miles a year." (*Practical Entomologist*, Vol 1. No. 1.) A re-

markable peculiarity in the eastern progress of this insect was subsequently pointed out by the same writer, in 1866, namely, "that in marching through Illinois in many separate columns, just as Sherman marched to the sea, the southern columns of the grand army lagged far behind the northern columns." (*Ibid,* II. *p.* 14.) By the autumn of 1866 the beetle, which appears to have invaded the southwest corner of Wisconsin at as early a date as 1862 (*Ibid,* II. p. 101) had already occupied and possessed a large part of the cultivated and southern portions of that State; and in Illinois, if we draw a straight line to connect Chicago with St. Louis, nearly all the region lying to the northwest of that line was over run by it. In 1867 it had already crossed the eastern borders of Northern and Central Illinois into Western Indiana, and in 1868 it extended to Central Missouri and Southern Illinois. In 1869 its presence was reported quite generally over the State and it had even made its way into Ohio, appearing almost simultaneously in the northern and southwestern portions. Its advent in the northern part of the State is thus described by a correspondent of the *Ohio Farmer:* "Having crossed the Mississippi at Rock Island the insects soon traversed the State of Illinois and reached the shores of Lake Michigan, where they might have met a watery grave, but, unfortunately their course was only deflected southward, and there were other cohorts of the invaders traversing lower parallels, so that, by convergence, the force was multiplied; and great fears were anticipated by the potato growers of Northern Indiana and Ohio." These fears were subsequently justified. During the years 1869 and 1870 the insect was exceedingly destructive all through the Northwest, and continued its eastward march at an ever increasing rate. In July of the latter year it invaded the province of Ontario at two different points, namely, near Point Edward at the extreme south of Lake Huron, and opposite Detroit, near

Windsor, at the south-western corner of Lake St. Clair. During the spring and summer of 1871 the insect was unprecedentedly numerous. In March of that year the beetle was turned up in great numbers while the ground was being plowed, especially in fields that had been planted the previous year to late potatoes ; and it subsequently swarmed on the wing in the streets of St. Louis.

The northern columns continued to advance at a rapid rate. During the summer the Detroit river was literally swarming with the beetles, and they were crossing Lake Erie on ships, chips, staves, boards, or any other floating object which presented itself. They soon infested all the Islands in the west end of the Lake, and by June were common around London, and finally occupied the whole country between the St. Clair and Niagara rivers. In the States they reached in some places the borders of New York and Pennsylvania. The southern columns of the army lagged far behind. Though gradually spreading, the insect had not yet touched the extreme southern counties of Missouri, and made its first appearance during the year 1871 in Phelps, Reynolds, Wright, Dent, and Texas counties. In 1872 its injuries were much less severe in the West, owing to the action of its natural enemies, and the free use of Paris green, but its eastward march continued. It extended into Cattaraugus county, N. Y., and obtained a foothold as far east as Lancaster Co., Pa. The Southern columns reached beyond Louisville, Ky.

In 1873 the advance guards of the vast army pushed to the extreme eastern limit of New York, and detached colonies made their appearance in the District of Columbia and in W. Virginia.

Early in the summer of 1874, I received undoubted evidence of its appearance on the Atlantic seaboard, and it was reported during the year from several parts of Connecticut, New Jersey, New York, Pennsylvania, Delaware, Maryland and Virginia.

Its injuries also increased in its native home in the Rocky Mountains. It had formerly been observed by many western travelers that the potatoes in the Mountain regions of Colorado were less affected by the insect than were those of the Mississippi Valley. This was natural enough, since the wild food plants are common there, and the potato fields fewer, and more scattered than further east; and moreover the stream which first branched off from the wild Solanum feeders and took to feeding upon the cultivated potato, and spreading eastward, doubtless at first took no backward course. During the summer of 1874, however, the insect did great damage to the crops of its native region in all fields below the middle elevations.

The summer of 1875 in Missouri and adjacent States was so excessively wet that although the beetle was abundant enough in the spring, it subsequently became comparatively scarce and harmless, and did not again become multiplied till after the rains had ceased and the third brood had developed; by which time the crop was sufficiently matured to be out of danger. Very much the same conditions occurred all over the upper Mississipi Valley country, and as there was an increased acreage planted, the crop throughout this whole section was larger and prices lower than they had been for many years. In the Atlantic States the insect attracted much more attention. From almost all parts of New York, New Jersey, Pennsylvania and Virginia, accounts came of the excessive numbers in which the pest made its appearance in the months of May and June. Local papers throughout the States mentioned, published records of the insect's injury, and laid the experience that had been gained in the States to the West before their readers; while even large city dailies, like the *World* and *Herald* of New York, devoted column after column to Doryphora's consideration. Judging from the mass of accounts,

the first brood was very generally neglected by those who had not before had experience with the insect, and not till the more numerous second brood appeared did the farmers awake to the importance of action, and, as far as possible, concerted action. Much injury was consequently done.

Later in the season the beetle at times swarmed in and about the large cities, and was commonly seen flying in the streets of Philadelphia and New York, as in past years it had been seen in those of St. Louis. Mr. J. J. Dean, of New York, after referring to its frequency in the streets of Brooklyn, gave me the following interesting account of its occurrence on Coney Island.

> On the 14th of September I picked up the enclosed specimen at Coney Island. The beach for miles was covered with them—the hummocks and sand-hills which comprise the greater part of the Island were literally alive with them. In the towns of Flatbush and Gravesend, both situated in King's Co.—the latter town including Coney Island within its boundaries—the ravages of this insect have been very serious. The Egg-plant seems to have afforded him his favorite article of diet. I am however puzzled by the fact that so many millions of them desert the fertile fields of Flatbush and Gravesend and steer for the barren acres of Coney Island, on which the principal vegetation is a coarse sea grass which they do not seem to touch. They appear to have an irresistible tendency to travel East, and are only stopped by the waves of the Atlantic Ocean.

In the Fall the insect reached up into Vermont and extended to within a few miles of Boston, but had not yet occurred in Maine.

During the present year, 1876, the insect has swarmed in most of the New England States, and especially on the sea shore. It has extended north around Montreal, and was especially abundant as far as Trois Rivières ; *) while in its eastern progress it has overrun Connecticut, Massachusetts, Vermont and New Hampshire, and extend-

* L. Provancher in *Naturaliste Canadien*, Aug. 1876, p. 249.

ed some distance into Maine. At Milestone and other places in Connecticut the beetles were washed ashore in such numbers in September as to poison the air, and the captain of a New London vessel found that they boarded him in such numbers while at sea that the hatches had to be closed. At many watering places, such as Cape May, Coney Island, Long Branch, Rockaway and Newport, they proved a great nuisance, being crushed and killed in large numbers by the continual promenading along the beach. The New York *Times* reported their impeding the progress of a train on the Central Railroad at Grinnell Station: "the rails were covered with them for a mile and after a few revolutions of the drivers the wheels lost the friction and slipped as if oiled; * * * they had to be swept off, and the track sanded before any progress was made."

THE INSECT'S NATIVE HOME.

As in the case of all insects that spread or are introduced from one section of country to another, it is interesting to know the original home or range of the Colorado Potato-beetle, so far as such can be learned, though the question has no especial practical bearing.

Up to the autumn of 1865 it was generally supposed by economic entomologists, that this destructive insect had existed from time immemorial in the Northwestern States, feeding upon some worthless weed or other; and that of late years, from some unexplained cause, it had all of a sudden taken to attacking the potato-plant.

They had however confounded with it an allied species, described further on as the Bogus Colorado Potato-beetle, and which never attacks the cultivated potato.

Following Walsh, I have always believed that this species, which has gradually spread to the Atlantic, originally came from the mountain regions of Colorado, and the reasons given are sufficiently convincing to have been very

generally accepted as valid. Nevertheless Prof. Cyrus Thomas questions the soundness of the theory in the following language, which I quote because Mr. Thomas's views are entitled to careful consideration:

> The first we hear of its attacking the potato, so far as I can ascertain, is in 1859, at which time it was in Nebraska, about 100 miles west of Omaha; the next we hear of it is in Iowa, in 1861, from which point its progress has been carefully noted. Now, it is not contended by any one that it travels except from potato patch to potato patch. That it manages in some way to get over intervening spaces of a few miles, is admitted, but never over spaces which require the production of intervening broods. Previous to 1859, as is well known, there was an intervening space between the border settlements of Nebraska and the eastern base of the mountains of two or three hundred miles in which there were no potato patches. How are we to account for it bridging this space; what induced it to take up its line of march across this barren region in which there were no settlements? Is it not much more reasonable to suppose the plains themselves formed its native habitat, and that as soon as the pioneer settlements reached this region and the potato was introduced, it commenced its attack upon it, and then began its march eastward along the cultivated area?
>
> *Western Rural, December* 4, 1875.

The weak points in the above reasoning are that it implies, first, that the insect travels only from potato patch to potato patch, and that there must have been potatoes at every few miles between the point west of Nebraska, where the beetle was first noticed on cultivated plants, and the mountains; second, that no cultivated potatoes were grown on said plains. In truth, however, potatoes were undoubtedly grown around Fort Kearney and other forts and settlements prior to that time, and the beetle may travel by the spreading of other wild species of *Solanum*, and by being carried along water courses or on vehicles. One point that may be urged in favor of the supposition that the insect was indigenous to the plains that reach far eastward into Kansas and Nebraska, is that it was unobserved in potato fields by certain parties in

parts of Colorado after it had reached as far as Iowa. The point is, however, weakened by the fact that it was found in great abundance in Colorado by Drs. Velie and Parry in 1864. Another point that may be made is that it is difficult to imagine that an insect, with such a natural predilection for *Solanum tuberosum*, could have passed from settlement to settlement across the plains without its depredations being noticed and recorded. But this last point may also be turned against Prof. Thomas's supposition, since it is also just as difficult to imagine that the potato patches that have been grown in restricted localities on the plains should have remained untouched, if the insect had always existed on those plains. Moreover, since potatoes were cultivated on the eastern borders of the plains in Nebraska and Kansas long prior to 1859, there can be no good explanation why the insect did not sooner commence its eastward march, except on the theory of a natural barrier in the shape of the more barren plains, which had up to that time prevented its advance from more western confines.

Mr. Thomas, in support of his views, supposes that the Sand bur (*Solanum rostratum*) originally occurred over the plains in question, citing as proof Gray's statement that it is wild on the Plains West of the Mississippi, and the localities given by Porter and Coulter in their *Flora of Colorado*. Dr. Gray's language is altogether too general to help much in the argument, and refers to the range of the plant ten years after the beetle had appeared in Nebraska. Porter and Coulter's localities are all in Colorado, and their "Plains of the Platte," doubtless refers to the south fork of that river. At all events, nothing is more certain than that the original home of the plant was the more fertile portions of the mountain region, and that, like the beetle which it nourished, it has been for many years extending its range eastward through man's agency in one way and another, and is now rapidly

extending across Missouri, where but a few years back it was entirely unknown. Mr. Carruth, of Topeka, says that prior to 1864, it was unknown in Kansas, and Mr. C. W. Johnson, of Atchison, writes me that the coming of Doryphora and of the weed in question were cotemporaneous in that section; that the northern dispersion of the plant from the South-west, through the Texas cattle traffic, afforded the means by which the beetle passed the great stretches of prairie lying east of its native haunts.

Bearing in mind that as early as 1824 Say reported the beetle sufficiently common on the upper Missouri, and that it flourishes most in the more northern of the States, I think we may justly conclude that the native home of the species is the more fertile country east of the mountains, extending from the Black Hills to Mexico, where it becomes scarce, and is represented by *Doryphora undecemlineata* and *D. melanothorax*. Putting all the facts together, we may also conclude that it crossed the great plains through man's agency. That it first reached the more fertile cultivated region to the east, in Nebraska, finds explanation, perhaps, in the fact that travel was greatest along that parallel, and that the insect's natural range extended further eastward in those more northern parts, just as the mountain region does in Wyoming and Dakota.

On the whole, Walsh's theory is doubtless at fault, and needs modification in so far as it implies that the insect necessarily came from Colorado; still I can but think that our Doryphora came from the Rocky Mountain region, and that civilization, in the way of traffic, travel, and settlement on the plains, was the means of bringing it, and that if we put not a too strict construction on his language, Walsh's views are in the main correct.

RATE AT WHICH IT TRAVELED.

Walsh estimated, from the rate at which it traveled in the earlier history of its march, that it would reach the Atlantic in 1881. From subsequent calculations I placed the date at 1878, but it in reality touched the Atlantic seaboard at many different places in 1874. It thus spread at an average annual rate of about 88 miles. But the annual rate was by no means uniform. Earlier in the history of its march the rate was much lower, and, until it got east of the Mississippi, did not average fifty miles. A glance at the map accompanying this pamphlet will suffice to show that, as indicated on p. 20, the line of most rapid spread was along the line of greatest human travel and traffic. In fact, after it had reached New York it began to extend and swarm both north and south along the coast, before many of the inland counties on similar parallels were reached by the main line of the immense army.

HOW IT TRAVELED.

As the larva is sluggish and never leaves the plant from which it is hatched, except in quest of more food, until it is ready to pupate, all the journeys of this insect are necessarily made in the perfect or beetle state by means of the ample rose-colored wings, which, when the insect is at rest, are compactly folded up beneath the striped wing-cases. Its spread, however, over the more populous portions of the country, is not to be attributed to its powers of flight alone. It undoubtedly availed itself, to no inconsiderable extent, of every means of transportation afforded to other travelers, and often got a lift on eastern bound trains, and, as we have seen, (p. 20), most probably crossed the more barren plains bordering its native confines through man's direct agency, i. e. by being carried. There is a possibility that in some instances it

may have been carried in the egg state on living plants, or in the pupa state in lumps of earth ; but these modes of transit, if they have occurred at all, have necessarily been exceptional. Even the winds and waters aided its progress. Its invasion of Canada took place at precisely the two points where we should expect to first meet with it in the Dominion, namely, at the extreme south of Lake Huron, and at the south-western corner of Lake St. Clair ; for all such beetles as fly into either of the lakes from the Michigan side would naturally be drifted to these points, and be washed to the shores of the St. Clair and Detroit rivers. As we know from experience, many insects that are either quite rare, or entirely unknown on the western side of Lake Michigan, are frequently washed up along the Lake shore at Chicago ; and these are so often alive and in good condition, and so often in great numbers, that the Lake shore is considered excellent collecting ground by entomologists. In like manner locusts are often washed up on the shores of Salt Lake, in Utah, in such countless numbers that the stench from their decomposing bodies pollutes the atmosphere for miles around. I have not the least doubt, therefore, in view of these facts, that the Colorado Potato-beetle could survive a sufficient length of time to be drifted alive to Point Edward, if driven into Lake Huron anywhere within twenty or thirty miles of that place, or if beaten down anywhere within the same distance while attempting to cross the lake.*

We have already seen, (p. 14), how in 1870 the beetles crossed Lake Erie on ships, chips, staves, boards and any

* The following item which was clipped from the St. Joseph (Mich.) *Herald*, attests the accuracy of the inference:—"Whoever has walked on this shore of Lake Michigan has observed large numbers of the Colorado Potato-beetle, crawling from the water. Many have doubted the source whence they came. It would seem from the following that they fly and swim from the western shores of Lake Michigan. Capt. John Boyne of the Lizzie Doak, reports finding his deck and sails infested with potato bugs when half way from Chicago to St. Joseph at night. Not a bug was on deck when the schooner left Chicago."

other floating object that presented itself, while the Detroit river literally swarmed with them.

An incident related to me by Jno. Hurlburt, Jr., who was engaged at the time in surveying and prospecting on the southern shore of Lake Superior, will illustrate how great a distance the beetles may extend without food when aided by water: he found them in immense quantities on a potato patch belonging to some Indians on the Menomonee river; yet this potato patch was in a clearing of about twenty acres, with no other clearing near; and to his certain knowledge there could not have been another potato patch within one hundred and fifty miles.

Many insects that are subject to very great multiplication, though not naturally migratory, often acquire the habit of migrating in swarms from one part of a country to another; and the migrating tendency has at times been quite marked in our Doryphora during its eastward march. This tendency is particularly noticeable in the last or Fall brood, and I have seen the beetles in autumn, swarming in the air or traveling in immense armies on foot—all instinctively taking the same direction, which is indeed a peculiarity of all animal migrations. There can be little doubt, therefore, that the larger areas have been traversed by this insect in the latter part of the growing season.

IT SPREADS, BUT DOES NOT TRAVEL IN THE SENSE OF LEAVING ONE DISTRICT FOR ANOTHER.

Let it not be understood that this insect, in its onward spread, or march, ever entirely quits any district where it has once obtained a foothold. This idea of its itinerant character seems very generally to prevail, and a great many people labor under the impression that soon after its advent, this dreaded foe to the potato will of its own accord take its leave as suddenly as it came—that, like every other dog, it will have its day. This idea is rather encouraged,

though I believe unintentionally, by Dr. LeBaron in his first Illinois Entomological Report, where he gives it as his opinion that the beetle will in time disappear, "especially in those localities where it is most abundant, even though we leave the work wholly to Nature." Nothing could, however, be farther from the truth, or less in accordance with past experience. It may, and very generally does, prove more injurious during the first two or three years of its advent than subsequently; because time is required for its natural enemies to multiply sufficiently to keep it in check. But wherever it once obtains a footing, there it may be expected to remain for all time to come—vascillating, it is true, from year to year, in numbers and consequent power to do mischief, according as the conditions for its increase or decrease are favorable; but always present to take its chances in the great struggle for existence, and to get the upper hand if it can.

AREA INVADED BY IT.

From the foregoing account it is manifest that this pernicious beetle has spread over an area of nearly 1,500,000 square miles, or considerably more than one-third the area of the United States. It has traveled over two-thirds of the continent in a direct eastern line, and at least 1,500 miles of this distance since 1859. It occupies at the present time, more or less completely, the States of Colorado, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Kentucky, Ohio, New York, Pennsylvania, District of Columbia, Virginia and West Virginia, Maryland, Delaware, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire and Maine, in none of which it was autochthonous except the first mentioned. If we wish to outline the whole territory now occupied by it, we must add to the above, parts of Wyoming and Dakota where it was native, and a large portion of Canada; and

the map at the beginning of this little work tells the story better than any words I can employ.

CAUSES WHICH LIMIT ITS SPREAD.

There are reasons why the Colorado Potato-beetle did not spread as rapidly along the line of its southern as along that of its northern march. The first is, that the potato is not in such general cultivation along the latter as along the former parallel, and potato fields are therefore more scattered; the second, that the insect was northern rather than southern in its native habitat; the third, that it suffers and does not thrive where the thermometer ranges near 100° F. The larvæ frequently perish under such a broiling sun as we sometimes have at St. Louis, and during very hot, dry weather, it frequently fails, as it did in 1868, to successfully go through its transformations in the ground, which becomes so hot and baked that the pupa dries out, and the beetle, if it succeeds in throwing off the pupal skin, fails to make its way to the surface. For these reasons it may never extend its range very far south of the territory now occupied. Its northern spread is not limited by any such cause, and the intensity or length of the winter will hardly affect it except in reducing the number of possible annual broods and consequently its power of multiplication. The state of dormancy once entered into may continue a month or two, more or less, without seriously affecting most insects. We may expect, therefore, to see it push to the northermost limit of the potato-growing portion of the country—a limit which it has already well nigh reached.

The question whether it will extend further westward and reach the Pacific, is a more interesting one. There is the best reason for believing that the Rocky Mountains furnish an impassable barrier to it, as they do to so many other insects. It has already been shown (p. 15) how po-

tatoes in the mountains were for years less affected than were those of the Mississippi Valley; but that in 1874 the insect proved quite injurious to those of the mountain region of Colorado. The fact is well established that it has not reached more than three or four miles into the mountains, or to about the middle elevations—say 8,000 feet above the sea level. The reason is that the atmosphere above that level is so dry and attenuated, that, taken in connection with the cool nights, the eggs, or the larvæ that succeed in hatching from them, shrivel and dry up. We have here, therefore, a physical barrier to its further westward progress, and the beetle is no more likely to reach California without man's direct assistance and carriage than it is to cross the Atlantic Ocean without the same means. Whether it could thrive on the Pacific Coast where the summers are so dry, is another question; but I fear it would hold its own, in many portions, if once introduced. In this connection it will be well to state that geographical races of *Doryphora* 10-*lineata*, differing in no very important characters from the typical northern specimens, occur in S. Texas, New Mexico, Arizona and Mexico, though they seem to have no more acquired the potato-feeding habit than *D. juncta* has done.

HOW IT HAS AFFECTED THE PRICE OF POTATOES.

During the earlier years of the insect's devastations in the Mississippi Valley, it materially affected the price of potatoes, not only by its direct ravages, but by discouraging farmers from attempting to cultivate the crop on an extensive scale. In 1873 the price reached the high figure of $2.00 per bushel (wholesale) in the St. Louis market, and many a family had to forego the luxury of a product which a few years before had been one of the cheapest of the farm, and so abundant as to enter largely into the feed of all kinds of stock. At the present time, with the improved methods of fighting the enemy, there is no

longer the same dread of it in the Western States that formerly existed : its management is considered part of potato-culture, and its natural enemies assist man to that degree that its effect on the crop is less felt. The quality of the tuber was very seriously affected through the defoliation which the vines so generally endured, and it was at one time difficult to get a non-watery potato on our western boards.

THE MODIFICATION IT HAS UNDERGONE.

Under the head of food-plants it will be presently shown how the species, as it spread over the country, became modified in habit, and increased the number of its food-plants. It has also undergone considerable modification in character. Specimens which I have examined from different parts of the country, show great variation in the marks of the thorax, in size, in coloration, and even in the ornamentation of the elytra, or wing-covers, and legs. The yellow varies from deep gamboge to almost pure white, the black line along the elytral suture is either very distinct or as obsolete as in *juncta ;* while some specimens have the pale legs and the femoral spot, more or less distinct, which are so characteristic of this last. In northern Iowa and Wisconsin I have seen millions traveling over the ground, the average size of the individuals being not more than half that of the more typical specimens ; and the general ground-color being white rather than yellow. In its southern range the colors tend to brighten and the black to become more metallic. Indeed the variation which it has already exhibited furnishes interesting material for the close species makers ; but it will suffice here to indicate that it exists : its consideration more in detail, belongs elsewhere.

ITS NATURAL HISTORY.

The natural history of this insect was first made known by the author in the columns of the *Prairie Farmer* for

August 8th, 1863. Subsequently, in 1866, Dr. Shimer of Mt. Carroll, Ill., detailed some additional particulars bearing on its habits, in a paper which he published in the *Practical Entomologist*, (Vol. I. pp. 84–85). The Colorado Potato-beetle hibernates in the perfect state, beneath the surface of the ground, or under any rubbish or other shelter that it can find. It has been exhumed from depths varying from a few inches to several feet, though its habit is not to burrow deeper than ten inches. The beetles are often dug up or plowed up in April, and they issue from their winter quarters soon after the ground thaws out, and at this season fly readily during the warmer parts of the day, making aërial journeys of considerable extent.

In flight the striped elytra are raised and held motionless from the thorax, while the gauzy wings, unfolded and vibrating, strike pleasantly on the eye as the sun intensifies their rosy hues.

The females begin to lay their eggs upon the young potato plants—mostly on the underside of the leaves—as soon as the latter appear above ground, and will often work into the ground to feed upon the young leaves before these have fairly shown themselves. The eggs are oval, of a translucent dark orange color, and are deposited in clusters of from 10 to 40 on the under sides of the leaves. The larvæ are hatched in less than a week, and are at first of a dark Venetian red, becoming lighter and acquiring a double row of black lateral spots as they approach maturity. The legs, head and posterior half of the first joint are also black. In from two to three weeks these larvæ acquire their full growth, after which they enter the earth and undergo their transformations, first to the pupa and then to the beetle state, which last is assumed in about a month from the time of hatching. There are three broods or generations each year in the latitude of St. Louis: yet it may be found at almost any time

during the summer in all its different stages. This is owing to the fact that the eggs in the ovaries continue to develop, and are laid in small batches at short intervals during a period of about 40 days in summer. The number produced by a single female averages from 500 to 700, but has been known to reach over 1,000. The whole cycle of transformations from the egg to perfect beetle rarely requires more than a month, and the last brood of beetles issue from the ground early in the fall, and, as we have just seen, enter it again to pass the winter.

ITS POISONOUS QUALITIES.

This question has been much and freely discussed in the columns of the agricultural press since the year 1866, and the war of divided opinion and diverse experience has waged briskly. That the juices of the insect on the human skin, are, as a rule, harmless, is proven by the hosts of farmers who have, with impunity, crushed the pest by hand ; indeed, scarcely any one who has had experience believes the wild stories of the poisonous nature of these juices. Yet the rule is not without exceptions ; there is no doubt that, with blood in certain bad conditions, persons have been poisoned by getting said juices into wounds or cuts. But the cases of undoubted poisoning by this insect—cases that have in some instances been serious and even proved fatal—are not from the juices of the body, but from the exhalations resulting from the *bruising* or crushing of large masses ; especially by burning or scalding large quantities at a time. The poison seems to be of a very volatile nature, and to produce swelling, pain, and nausea, very much as other animal poisons do. In the writer's reports, as well as in the first report of Dr. Wm. LeBaron, formerly State Entomologist of Illinois, authentic instances of such poisoning are recorded. Therefore, while there can be little danger in the cautious killing of the insect in the field, it should

not be recklessly handled in large quantities, and its destruction, in such quantities, by scalding or burning, should be especially avoided.

Some interesting experiments, to test the poisonous qualities of these insects, were made in 1875 by Messrs. A. R. Grote and Adolph Kayser, and reported in a paper entitled "Are Potato Bugs Poisonous?" read before the American Association for the Advancement of Science at its meeting in Detroit. The experimenters conclude that the reported cases of poisoning resulted rather from the arsenic used in destroying the insect, or from carbonic oxide produced by incomplete combustion when large numbers of the beetles are thrown into a fire. It is to be hoped that the experiments will be continued, because, so far, they by no means cover the whole ground; we have yet to learn what the active principle is which produces the physiological effect that has been well attested, and the precise conditions under which it acts.

It is worthy of note that Prof. A. J. Cook, of the Michigan Agricultural College, from experiments somewhat similar to those of Messrs. Grote and Kayser, has been led to form conclusions quite opposite to those arrived at by these gentlemen.

ITS FOOD PLANTS.

In its native home the Colorado Potato-beetle fed upon the few wild species of *Solanum* found there, especially *S. rostratum* and *S. cornutum*. It still often shows a preference for these wild plants to the cultivated potato. For a number of years it was thought that the insect was incapable of flourishing on any other plants but those of the Night-shade Family (*Solanaceæ*), and more especially upon those of the Night-shade genus proper, (*Solanum*), which includes the Egg Plant, the Horse-nettle, and some other wild species west of the Mississippi, which are known by various popular and local names. Upon the

Horse-nettle, (*S. Carolinense*), which is common in Missouri and east of the Mississippi, but is mostly replaced in Kansas by the *S. rostratum*, it seems to delight even more than upon the potato, and it has been found quite injurious to other plants of the same genus, such as the *S. Warscewiczii*, *S. robustum*, *S. discolor*, and *S. Sieglingii* which are often cultivated for their ornamental foliage. The other common plants of the family, such as the Tomato, (*Lycopersicum*), Ground cherry, (*Physalis*,) Thorn apple, (*Datura*), Henbane, (*Hyoscyamus*), Apple of Peru, (*Nicandra*), Tobacco, (*Nicotiana*), Belladona, Petunia, and Cayenne Pepper are not over much to its liking, though upon a pinch it will feed upon all of them, and especially the first named. Dr. Le Baron observed that the Cayenne pepper, if eaten to any extent, was actually poisonous to it.

Under these circumstances it is interesting to note (as showing how new habits may be acquired under favorable conditions), that as the insect became more and more acclimated east of the Mississippi, it acquired the power to feed on a greater variety of plants, and did not even confine its depredations to those belonging in the natural Order *Solanaceæ*. In 1871 it was found by several parties feeding and even breeding in considerable numbers on Cabbage. It would be sad indeed if so important an esculent should in the future be doomed to suffer with the potato, from the insatiable appetite of such a pest; and though I have no idea that cabbage raisers need fear anything of the sort, yet stranger things have happened.

In 1874 Mr. Henry Gillman, of Detroit, Michigan, added to the list of its food plants several new species, on which, in one state or another, he found them feeding. I quote the following from a letter in which he recounted to me these observations, with the remark that the fact of finding the eggs on a plant, or the insect sparingly nibbling the same, does not prove that it could live and thrive on

such plant, as a species, any more than the fact that a cow at times partakes sparingly of animal food proves that she could sustain life on a flesh diet. Yet the facts communicated by Mr. Gillman are interesting, as showing the tendency to which I have before alluded, toward a change of habit from year to year, as the insect changes and extends its habitat:

I found the *Doryphora* 10-*lineata*, Say, at Port Austin, Michigan, on June 19, 1872, feeding sparingly on young grass (too immature to determine its species), on which the insect had deposited its eggs. This was generally, though not always, in potato fields or their vicinity. On July 20 (about a month later) I found the insect at Fort Gratiot, Michigan, in large numbers, both larva and perfect states, in the vicinity of potato fields which it had almost destroyed, devouring the young leaves and flower-buds of the common thistle, (*Cirsium lanceolatum*, Scop.), which it was rapidly stripping. In the same neighborhood I saw it on Pigweed, (*Amarantus retroflexus*, L.), Hedge Mustard, (*Sisymbrium officinale*, Scop.), the cultivated Oat, Smartweed, (*Polygonum Hydropiper*, L.), and the Red Currant and Tomato of the gardens, as well as the common Night-shade, (*Solanum nigrum*, L.); of which, with the exception of the Night-shade, its more legitimate food, it ate only the young leaves, and of them very sparingly. Two or three weeks later I found the thistles devoured by it even to the thick stems, so that all the leaves were stripped off, and the entire tops of the plants hung down, almost severed. About the same time I saw the insect feeding on the maple-leaved Goosefoot, (*Chenopodium hybridum*, L.), Lamb's quarter, (*C. album*, L.), and Thoroughwort, (*Eupatorium perfoliatum*, L.), and on August 8, 1872, I found it, in both the larva and perfect states, voraciously eating the Black Henbane, (*Hyoscyamus niger*, L.), on which was also to be seen an abundance of the eggs. As the last mentioned plant is not native, having been introduced from Europe, the beetle's fondness for it is more noteworthy.

Mr. A. W. Hoffmeister, of Ft. Madison, Iowa, an entomologist, the accuracy of whose observations may be relied on, wrote during the same year:

Last year, after all the early potatoes had been taken up and the late ones either wilted through excessive dryness or eaten up by

the Colorado gentleman, I was astonished to find so many 10-lined spearmen in the lower part of town, while in the upper part they were reasonably scarce; but I was more astonished to find that the larvæ had stripped the *Verbascum* of its leaves.

The Mullein, belonging to the Figwort family, must therefore be added to the list of plants on which the insect lives and flourishes. An item went the rounds of the papers during that year to the effect that Alfalfa was greedily devoured by the insect, but just how much credit should be given to the statement, which originated with a Montana correspondent of the *Farmer's Home Journal* of Kentucky, it is difficult to say. Probably the reference was originally made to the old-fashioned "potato-bugs," or blister-beetles, which are common in the Western country and very general feeders.

This growing ability to adapt itself to a greater variety of food-plants will render its extermination and control all the more difficult.

Several instances came under my notice where the beetles, in early spring, entered hot-beds in great numbers and devoured tender tomato and egg-plants.

Among the Potatoes, the tender leaved varieties, such as the Shaker Russet, Mercer or Meshannock, Pinkeye, and Early Goodrich are most affected, while the Peach Blow, Early Rose and the like enjoy comparative immunity, especially when grown in the same field with the more tender varieties which attract the greater proportion of the pests.

THE BEETLE EATS AS WELL AS THE LARVA.

As the statement has been quite frequently made that the beetle does not feed, and that consequently there is nothing to fear from it early in the year, the fact may as well be reiterated that the beetles do feed, though not quite so ravenously as the larva. But as they are on hand as soon as the young plants peep through the ground,

and as these first spring beetles are the source of all the trouble that follows later in the season, it is very important to seek and destroy them.

ITS NATURAL ENEMIES.

Persons not familiar with the economy of insects are continually broaching the idea that, because the Colorado Potato-beetle is in certain seasons comparatively quite scarce, therefore it is about to disappear and trouble them no more. This is a very fallacious mode of reasoning. There are many insects—for instance, the notorious Army-worm of the North, (*Leucania unipuncta*, Haworth),—which only appear in noticeable numbers in particular years, though there are enough of them left over from the crop of every year to keep up the breed for the succeeding year. There are other insects—for instance the Spring Canker-worm, (*Paleacrita vernata*, Peck),—which ordinarily occur in about the same numbers for a series of years, and then, in a particular season and in a particular locality, seem to be all at once swept from off the face of the earth. These phenomena are due to several different causes, but principally to the variation and irregularity in the action of cannibal and parasitic insects. We are apt to forget that the system of Nature is a very complicated one—parasite preying upon parasite, cannibal upon cannibal, parasite upon cannibal and cannibal upon parasite—until there are often so many links in the chain that an occasional irregularity becomes almost inevitable. Every collector of insects knows, that scarcely a single season elapses in which several insects, that are ordinarily quite rare, are not met with in prodigious abundance ; and this remark applies, not only to the plant-feeding species, but also to the cannibals and the parasites. Now it must be quite evident that if, in a particular season, the enemies of a particular plant-feeder are unusually abundant, the plant-feeder will be greatly diminished in numbers, and

will not be able to expand to its ordinary proportions until the check that has hitherto controlled it is weakened in force. The same rule will hold with the enemies that prey upon the plant-feeders and also with the enemies that prey upon those enemies, and so on *ad infinitum*. The real wonder is, not that there should be occasional irregularities in the numbers of particular species of insects from year to year, but that upon the whole the scheme of creation should be so admirably dove-tailed and fitted together, that tens of thousands of distinct species of animals and plants are able permanently to hold their ground, year after year, upon a tract of land no larger than an ordinary State.

To the naturalist it has been interesting to watch how, with the advance of the Doryphora toward the East, the number of its natural enemies has increased. The farmer should learn to distinguish these his allies, and to encourage them.

Several birds are known to feed upon both beetles and larvæ. Among these is the Crow, which not only takes the beetles from the potato vines, but late in the season digs into the earth in search of the hibernating individuals. The common quail too, that blythe and pretty field companion, whose services as an insect gatherer have been altogether underrated, performs the same service for us.

In July, 1872, Prof. C. E. Bessey, of Iowa Agricultural College, wrote me word that he found the Rose-breasted Grosbeak, (*Guiraca ludoviciana*), devouring the Potato-beetles, and soon afterward, the same bird was sent to me by E. H. King, of Steamboat Rock, Iowa, with a similar statement. Other persons, especially in Iowa, observed the same trait in this bird, which, though formerly quite rare, seems during that year to have suddenly multiplied and acquired this habit. Mr. Joel Barber, of Lancaster, Wisconsin, informed me that this bird, though seldom seen there before, was quite common in that vicin-

ity about the first of June, breeding there, and clearing potatoes of the nasty "bugs," which it seemed to prefer to all other food. Ever since than it has effectually assisted the northwestern potato-growers in protecting his fields.

The Rose-breasted Grosbeak is a beautiful and conspicuous bird, the male having a heavy bill, with black head, black back, varied with brown, and black wings, the latter with three white bands. Some of the outer tail-feathers and parts of the abdomen are white, and the breast is rose-red.

Among domesticated birds, the duck was for several years the only species that would touch the nauseous insects, and for a long time chickens would invariably give them the go-by. After a few years, however, chickens learned to eat, first the eggs, and then the larvæ, and finally acquired the habit of feeding upon the mature insects to such an extent that instances have been reported to me where between thirty and forty perfect beetles had been found in the crop of a single chicken, and this not from lack of other food but from preference.

Among quadrupeds there is good evidence that the skunk feeds upon them. That good garden servant, the common toad, (*Bufo Americanus*), often gorges itself with them, while the black snake and doubtless other reptiles in this respect keep it company.

Among spiders (*Arachnida*) an undetermined species of *Phalangium*, (Fig. 3 represents *P. dorsatum*, Say), has been seen preying upon our Doryphora larva. These animals are popularly called "Grand-daddy Long-Legs," in this country, but are also known as "Harvest-men," and "Grandfather Gray-Beards," in some parts. They all have similar habits, being carnivorous and seizing their prey very much as a cat seizes a mouse, but differ from other spiders in that they bodily devour their victims, instead of sucking out their juices. They are known to

devour great numbers of plant-lice, and Mr. Arthur Bryant, of Princeton, Ill., found them devouring the larvæ of our Colorado immigrant.

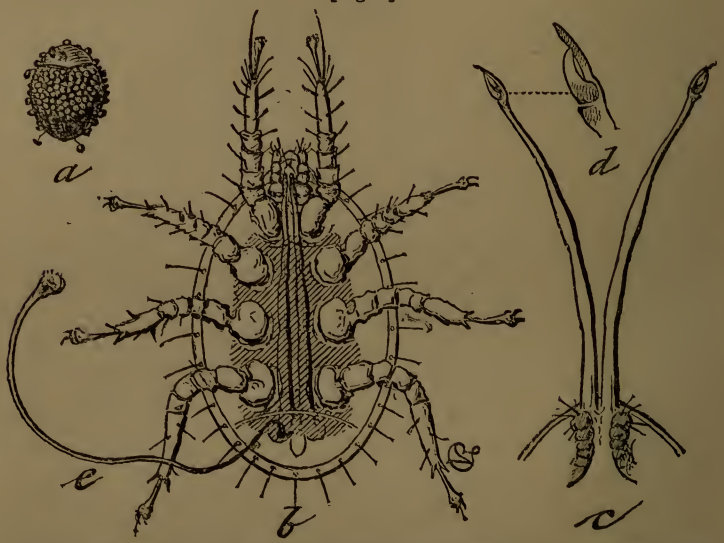
[Fig. 3.]

PHALANGIUM DORSATUM:—natural size.

Of mites, (*Acarina*), there is a very interesting species (*Uropoda Americana*, Riley), which is parasitic on the beetle externally. It was first sent to me by Mr. H. C. Beardslee, of Paynesville, Ohio, in 1873, and subsequently

found by Mr. W. R. Gerard, to very generally infest the beetles around Poughkeepsie, N. Y. It sometimes so thickly crowds and covers its victim that no part of this last is exposed, and the beetle thus infested languishes and eventually perishes. This minute parasite is about the size of the head of a small pin, broadly oval, depressed, the body in one piece, somewhat tough above, and

[Fig. 4.]



UROPODA AMERICANA:—*a*, Colorado Potato-beetle attacked by it—nat. size; *b*, the mite, ventral view, and showing the penetrating organs lying between the legs; *c*, the organs extended; *d*, the claw; *e*, the excrementitious filament—all greatly enlarged.

yellowish-brown in color. It is not uncommon on other beetles, and is closely allied to a well-known European mite parasite of beetles and other Articulates—the *Uropoda vegetans*. This last is described by authors as possessing the peculiarity of attaching itself to the hard, shelly parts of its victims by means of a thread-like filament that issues from the posterior part of the body. A careful study of our American species has convinced me that the similar anal filament, which also helps it to adhere

to Doryphora, is in reality excrementitious, sticking to the beetle and to the mite by a flattened disc at either end, being quite fragile and easily broken. The true penetrating organs, which enable the mite to hold tenaciously to its victim, and probably assist in obtaining nourishment, I have discovered to be a pair of extensile processes, each armed at the tip with a bifid claw somewhat resembling that of a lobster. When at rest these organs are retracted and lie between the legs and just under the skin. When extended, they are usually brought closely together and extend the whole length of the animal beyond the head. Thus, in addition to the more frail excrementitious and adhesive filament, this *Uropoda* is provided with an organ that is beautifully adapted to penetrating the hard covering of beetles, and of thus securing it to its slippery support.

The most effective natural enemies of our potato pest, are, however, found among insects proper, and—determined as man's warfare has been against it, with his mechanical appliances, and poisonous preparations—it is doubtful whether his efforts would have been availing without the aid of these tiny but by no means insignificant allies. A few prey upon the beetle, but the larger number attack the eggs and larvæ. I will give brief illustrated accounts of the more notable of them, according to their several orders :

Ord. *Hymenoptera.*—Though this, of all the Orders, contains the largest number of parasitic species, yet not one of them is known to attack the Doryphora, and the only Hymenopteron that has been observed to attack it is the Rust-red Social Wasp, (*Polistes rubiginosus*, St. Farg.), which has been seen to carry the Doryphora larva to its nest. The wasps of this genus, with their gray paper-like nests, are familiar objects. A solitary female or queen that has hybernated, founds the colony, feeding her larvæ on honey and various partly masticated insects.

Her immediate progeny is composed of females only, somewhat smaller than herself. There are no males in this summer brood, and the virgin females build a nest in

[Fig. 5.]

POLISTES RUBIGINOSUS:—*a*, wasp, *b*, spring nest.

common, and produce a fall generation, composed of both sexes, the large females of which, after impregnation, hibernate, and start, each one, a colony again the following spring.

Ord. *Coleoptera*:—This order furnishes quite a number of Doryphora's enemies, and first in importance among them are various species of Ladybirds, (*Coccinellidæ*). The following species have all been found by myself and others preying voraciously upon its eggs: 1.—The Spotted Ladybird, (*Hippodamia maculata*, DeGeer), which is one of our most common species, and is of a pink color, marked with large black spots as in Fig. 6. 2.—The Nine-spotted Ladybird, (*Coccinella* 9-*notata*, Herbst), which is of a brick-red color, and marked with 9 small black spots as in Fig. 7. 3.—The Thirteen-spotted Ladybird, (*Hippodamia* 13-*punctata*, Linn.), which is also of a brick-red color but marked with 13 black spots as in Fig. 8. 4.—The little species figured at 9, *c*, which may be known as the Con-

[Fig. 6.] [Fig. 7.] [Fig. 8.]

SPOTTED, 9-SPOTTED, AND 13-SPOTTED LADYBIRDS.

vergent Ladybird, (*Hippodamia convergens*, Guer.), and which is of an orange-red color marked with black and white, as in the figure. This last species alone has been of immense benefit in checking the ravages of the Potato-beetle. Its larva is represented of the natural size at Fig. 9, *a*, its color being blue, orange and black; when full grown it hangs by the tail to the underside of a stalk or leaf, and transforms into the pupa represented at Fig. 9, *b*. In this state it is of the exact color of the Colorado beetle larva, and is doubtless quite often mistaken for that larva, and ruthlessly destroyed. It may readily be distinguished, however, by its perfect repose. Let every potato grower learn well to recognize it and spare its life! 5.—The Icy Ladybird, (*Hippodamia glacialis*, Fabr.). This species, which was doubtless so named from occurring so far north, where it is often found under ice and snow, has likewise been seen in great numbers carrying on the same commendable work. Fig. 10, represents it of the natural size, the wing-covers being of a bright orange-red, each marked behind with three black spots, the two upper of which are confluent, and the head and thorax being black, marked with cream-yellow, as in the illustration. The species is closely allied to the Convergent Ladybird (differing principally in being nearly twice as large, and in lacking the spots on the anterior portion of the wing-covers), and will be found to have similar transformations. 6.—The 15-spotted Ladybird (*Mysia* 15-*punctata*, Oliv.). This is the largest of our true Ladybirds, and the only other species of the family that is larger, in this country, is the Northern Squash-beetle, (*Epilachna borealis*, Fabr.), a species which has the wing-covers spotted in a somewhat similar manner,

[Fig. 9.]

a *b* *c*

CONVERGENT LADYBIRD:—*a*, larva; *b*, pupa; *c*, beetle.

[Fig. 10.]

ICY LADYBIRD.

and which is common in some parts of the East. The 15-spotted Ladybird is a very variable insect, and at *d*, *e*, *f*, and *g*, (Fig. 11), are represented four of the more striking forms. In the more common form the thorax is cream-colored, and the wing-covers cream-colored, with a tinge of chocolate. In this form (*d*) the black spots and marks are conspicuous. In the next (*e*) the thorax re-

[Fig. 11.]

15-SPOTTED LADYBIRD:—*a*, larva, devouring its prey; *b*, pupa; *d*, *e*, *f*, *g*, beetle, showing variations—nat. size; *c*, shield on first joint of larva—enlarged.

mains the same, but the wing-covers are chocolate-brown, and the black spots are surrounded with a paler brown annulation. In the third form (*f*) the thorax is a little darker, and the wing-covers so dark that the spots are scarcely perceptible; while in the fourth form the whole insect is of a uniform deep brown-black color.

The larva of this beetle (Fig. 11, *a*) is jet black, with six rows of long spines and six long black legs. It has a paler yellowish stripe along each side, intercepted by two bright orange spots behind the legs, and there is also an orange spot on the back of the flattened first joint (*c*). When about to change, this larva fastens itself to the plant and changes to a cream-yellow pupa, marked with black, as at Fig. 11, *b*.

All these Ladybirds devour by preference the eggs of the Potato-beetle, and thus attack it in the most susceptible condition. The two larger species, and notably the last mentioned, also attack the Doryphora larva. The larvæ of all these Ladybirds are more bloodthirsty in their

habits than the perfect beetles, and the larva of the little Convergent Ladybird is so essentially cannibal, that whenever other food fails, it will turn to and devour the helpless pupæ of its own kind.* It is rather cruel, and withal a somewhat cowardly act, to thus take advantage of a helpless brother; but in consideration of its good services, we must overlook these unpleasant traits in our little hero's character! All these larvæ bear a strong general resemblance, and with the aid of Figs. 8, 9 *a*, 11 *a*, and 12, a good idea may be obtained of them. They run with considerable speed, and may be found in great numbers upon almost all kinds of herbage. The larvæ of certain species that prey upon the Hop Plant-louse in the East are well known to the hop-pickers as "black niggers" or "serpents," and are carefully preserved by them as some of their most efficient friends.

[Fig. 12.]

LADYBIRD LARVA

The eggs of Ladybirds greatly resemble those of the Colorado Potato-beetle, and are scarcely distinguishable except by their smaller size, and by a much smaller number being usually deposited in a single group. As these eggs are often laid in the same situation as those of Doryphora, the farmer should learn not to confound those of his best friends with those of his bitterest enemies. A practiced eye soon discriminates between them, and it is often on such minute discriminations that we must distinguish between friend and foe.

Next in importance, among the beetles, as enemies of Doryphora, come certain Tiger-beetles, (*Cicindelidæ*), and Ground-beetles, (*Carabidæ*), which are quick of limb, very voracious, and devour indifferently the larva or the beetle. I will illustrate a few that have been found doing

* This is so generally the case with predaceous insects, that the term "cannibal" is often employed by entomologists, and is sometimes employed in this work to designate the rapacious or insectivorous species.

this good work, though many others of the same family doubtless also prey upon the potato pest, as the different species are not at all particular as to diet.

1.—The Virginia Tiger-beetle, (*Tetracha Virginica*, Hope), which is of a dark metallic green color, with brown legs, and of which the annexed cut, (Fig. 13), will enable recognition to be made without much difficulty.

[Fig. 13.]

TETRACHA VIRGINICA.

2.—The Fiery Ground-beetle, (*Calosoma calidum*, Fabr.), is of a black color, with coppery dots, as shown in Fig. 14. Its larva is a black, elongate, six-legged creature known as the "Cut-worm Lion," on account of the avidity with which it hunts for, and destroys, those garden and field pests.

[Fig. 14.]

CALOSOMA CALIDUM.

3.—The Elongate Ground-beetle, (*Pasimachus elongatus*, Lec.), a pretty and conspicuous insect of a polished black color, edged with deep blue, and of a rather elegant form, (Fig. 15).

[Fig. 15.]

PASIMACHUS ELONGATUS.

4.—The Murky Ground-beetle, (*Harpalus caliginosus*, Say), which is of a dull black color, and which is represented life-size at Fig. 16.

[Fig. 16.]

HARPALUS CALIGINOSUS.

In 1871 the Great Lebia, (*Lebia grandis*, Hentz, Fig.

17), was found devouring the larvæ of Doryphora; and during the subsequent year this beetle, hitherto considered rare, was found to be very abundant in certain potato fields in Central Missouri, where it was actively engaged in destroying both the eggs and the larvæ of the same. The head, thorax, and legs, of this cannibal are yellowish-brown, in high contrast with its dark-blue wing-covers. Mr. P. R. Uhler subsequently found the Black-bellied Lebia, (*Lebia atriventris*, Say), a species of the same color and general appearance, but only half as large as *L. grandis*, destroying it around Baltimore.

[Fig. 17.]

LEBIA GRANDIS.

The same commendable habit is ascribed to the Kansas Bombardier beetle (*Brachinus Kansanus*, Lec.), an insect likewise bearing a general resemblance to the Great Lebia, but one third larger and more lengthened, and with the wing-covers of a duller, less polished blue. The beetles of this genus all have the power of discharging from the anus, when disturbed, an acrid fluid of so volatile a nature, that upon coming in contact with the air, it tenuates with an explosive noise and pungent smell, and hides the artilleryman in a bluish vapor which enables him to effect his escape. The species in question was first found attacking the Doryphora larvæ by Mr. Thomas Wells, of Manhattan, Kansas, who furnished me with specimens for identification.

To those above enumerated may be added a species of Rove-beetle, belonging to the genus *Philonthus*. An undescribed species of this genus was found by Dr. Shimer, killing the Doryphora larvæ in one of his breeding cages, and there is reason to believe that it follows the same habit when free in the field. The particular species noticed by Dr. Shimer was in the Walsh cabinet, which was destroyed in the great fire at Chicago, but to

give the reader a correct idea of this genus of insects I present a figure of *Philonthus apicalis*, Say, (Fig. 18). The larvæ are active and voracious, and bear considerable resemblance to the perfect insects. Fig. 19 is taken from Westwood, and shows that of *Goerius olens*. The pupæ are quiescent and incapable of motion, all the parts being soldered together and encased almost as firmly as in the chrysalis of a butterfly. The head and prothorax are suddenly bent forward, the former touching the breast, and the back is curiously flattened. Fig. 20 represents the pupa of an allied insect found in the ground and from which I bred *Quedius molochinus*, Grav. The rove-beetles are, as a general rule, carrion feeders, preying voraciously on decaying animal and vegetable substances; but some of them are true cannibals, while a few are even parasitic. Indeed they are no doubt more carnivorous than is generally supposed.

[Fig. 18.]

ROVE-BEETLE.

[Fig. 19.]

ROVE-BEETLE LARVA.

[Fig. 20.]

ROVE-BEETLE PUPA.

Finally, strange as it may seem, the Striped Blister-beetle and the Ash-gray Blister-beetle, which are very injurious to the potato, seem to have the redeeming trait of also preying occasionally on the larva of the Colorado Potato-beetle. It was first difficult to believe or reconcile the statements to this effect, but there have been so many of them, that the fact may now be considered as indisputable, and these two blister-beetles may therefore, with propriety, be added to the list of enemies. I by no means advise their protection, however, on this account; for I believe that what little good they accomplish is much more than outweighed by the injury they do us. As

authorities for these statements may be quoted, among many others, Abel Proctor, of Jo Daviess county, Ill., and T. D. Plumb, of Madison, Wis.

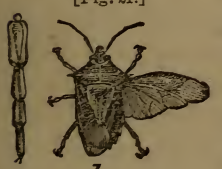
"When dog eats dog, then comes the tug of war;"

when rogues fall out, honest men come by their own.

Ord. *Hemiptera.*—All the insect enemies of our Potato-beetle so far mentioned destroy it by mastication with their jaws—all of them being possessed of powerful mandibles. The several true bugs, belonging to the Heteropterous division of the Order under consideration, obtain their food on the contrary by suction, piercing their victim with their sharp beak or proboscis. The following species are known to attack our Doryphora.

1.—The Spined Soldier-bug, (*Arma* spinosa*, Dallas). This is one of the most common and efficient of Doryphora's enemies, occurring in all parts of the country, and seeming to have a decided fondness for our potato-destroyer, especially for the soft larva. It is of an ochre yellow color, and is represented with one pair of wings closed and the other pair extended, in the annexed, Fig. 21. Thrusting forwards his long and stout beak, he sticks it into his victim, and in a short time pumps out all the juices of its body and throws away the empty skin. He belongs to a rather extensive group (*Scutellera* family) of the true bugs (*Heteroptera*), distinguishable from all others by the very large scutel, which in this genus is triangular, and covers nearly half the back. Most of the genera belonging to this group are plant-feeders, but there is a sub-group (*Spissirostres*), to which our cannibal friend belongs, characterized by the robustness of their beaks, and all of these seem to be cannibals. To illus-

[Fig. 21.]



a *b*

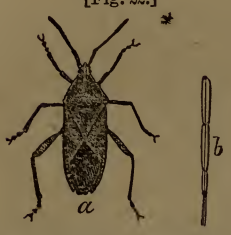
SPINED SOLDIER-BUG.—*a*, enlarged beak; *b*, bug, with right wings expanded.

* Belongs to the modern generic subdivision *Podisus*.

trate to the eye the difference between the beaks of the cannibal sub-group and the plant-feeding sub-groups of this family, Fig. 21, *a*, gives a magnified view of the beak of our insect seen from below, and Fig. 28, *c*, a similarly magnified view of that of a plant-feeder belonging to the same family (*Euschistus punctipes*, Say), which is so nearly of the same size, shape, and color, as our cannibal friend, that at first sight many persons would mistake one for the other. The Spined Soldier-bug, however, may be at once distinguished from all allied bugs, whether plant-feeders or cannibals, by the opaque brown streak at the transparent and glassy tip of its wing-cases.

It has sometimes been reported that the common Squash-bug, (*Coreus tristis*, DeGeer), preyed upon the Colorado Potato-beetle; but there can be very little doubt that the Spined Soldier-bug has in these instances been mistaken for it. The colors of the two are somewhat similar, but in the eyes of an entomologist the Squash-bug looks as different from the Spined Soldier-bug as a cow does from a horse! The figure (22, *a*), of the former, which is here given, compared with that of the latter, (Fig. 21), on the previous page, will enable any one to recognize the difference, while its magnified beak (Fig. 22, *b*), indicates by its slenderness that it is a plant-feeder.

[Fig. 22.]



SQUASH-BUG.—*b*, enlarged beak.

While treating of the Spined Soldier-bug, it will be well perhaps to state that though, with all true Bugs, its larva and pupa are active, and have the same habits and general form of the mature insect, yet they differ so much in coloration and pattern, that they are scarcely ever properly identified, and have often been sent to me as a new Potato-bug enemy by those who have found them boldly following out their naturally voracious instincts.

The eggs of this Soldier-bug are pretty, little bronze-colored, caldron-shaped objects, with a convex lid, around which ciliate fifteen or sixteen white spines (Fig. 23, *c*,). They are neatly placed side by side in clusters of a dozen or more upon leaves and other objects, and are so much subject to the attacks of a minute Hymenopterous parasite, that those who undertake to hatch such as are found out-doors will more often get flies than bugs. The newly-hatched bug is ovoid, and shiny black, with some bright crimson about the abdomen. In the full-grown larva, (Fig. 23, *b*), the black still predominates on the thorax, but some four yellowish spots appear, and the abdomen becomes more yellowish, though still tinted with red. In the pupa, (Fig. 23, *a*), which is readily distinguished by the little wing-pads, the ochreous-yellow extends still more, and finally, with the last molt, the black disappears entirely in the perfect insect. Throughout the immature stages the shoulders are rounded, and not pointed, and the antennæ or feelers have but four joints instead of five as in the mature bug, while there are but two visible joints to the feet or tarsi instead of three.

[Fig. 23.]

SPINED SOLDIER-BUG.—*c*, egg; *b*, larva; *a*, pupa.

We have been taught to admire the muscular power of the lion, which is enabled to grip and toss an animal larger than itself with its powerful neck and jaws; but feats performed by these young Soldier-bugs throw the lion's strength completely into the shade, for they may be often seen running nimbly with a Doryphora larva, four or five times their own size, held high in air upon their outstretched beak.

The Spined Soldier-bug by no means confines himself to Potato-beetle larvæ, but attacks a great number of other insects.

2.—An allied species, (*Arma* [*Podisus*] *cynica*, Say), of

the same color as the preceding, but about twice as large, and less common, has the same habit of feeding on Doryphora.

3.—The Bordered Soldier-bug, (*Stiretrus fimbriatus*, Say.)—This belongs to the same subgroup, and has the same kind of short, robust beak as the preceding, but unlike that species, it is so conspicuously and prettily marked that it cannot easily be confounded with any other. Its colors are dark olive-green and cream-color, marked as in Fig. 24. It is not so common as the preceding species.

[Fig. 24.]

Bordered Soldier-bug.

4.—The Many-banded Robber, (*Harpactor* cinctus*, Fabr.). This species is still more elegantly marked than the preceding. Like the Spined Soldier-bug, this species is common, and inhabits trees more commonly than herbaceous plants; but it belongs to an entirely different group of the true Bugs, (*Reduvius* family), all of which, without exception, are predaceous, and are characterized by a short, robust, curved beak. Fig. 25 gives a magnified view of this bug, the colors being yellow, white, and black, and it may be known by the name of the Many-banded Robber.

[Fig. 25.]

Many-banded Robber.—*a*, bug, enlarged; *b*, its beak, more enlarged.

5.—The Rapacious Soldier-bug. This bug, (*Reduvius raptatorius*, Say), belonging to the very same group as the preceding, is represented at Fig. 26. It is of a brown color and easily recognized. It likewise has the same habit.

* *Milyas*, Stäl.

6.—The Ring-banded Soldier-bug, (*Perillus circumcinctus*, Stäl), is the fifth member of this useful group.

[Fig. 26.]

RAPACIOUS SOLDIER-BUG.

This prettily marked insect, (Fig. 27, *b*, showing an enlarged view of its antenna, and *c*, of its beak), is of a rich polished brown color, marked as in the figure, with pale yellow. Underneath on the venter there is a large yellow patch containing four black spots quadrangularly arranged, and there is a border of yellow extending around the edge of the whole body. It is a not uncommon species.

[Fig. 27.]

RING-BANDED SOLDIER-BUG. — *a*, bug enlarged; *b*, its antenna; *c*, its beak still more enlarged.

7.—The Dotted-legged Plant-bug. This species, (*Euchistus punctipes*, Say, Fig. 28), is minutely speckled, and of an ochre-yellow color, and so closely resembles the Spined Soldier-bug that the reader is referred to the illustration of the latter to contrast with it. The most obvious features whereby to distinguish these two insects are those furnished by the figures, namely, the more flattened form of the Soldier-bug and especially of its quadrate head, and its sharp-pointed thorax. This last character is variable, in both, so that specimens of the former occur with the thorax rounded, and of the latter with it more or less pointed; but there are two other structural differences which are always constant and can always be relied on to distinguish the two insects. If the Spined Soldier-bug be examined underneath, its beak, (Fig. 21, *a*), will be found to be quite stout, especially at the base, and between the hind legs at the base of the venter, a

[Fig. 28.]

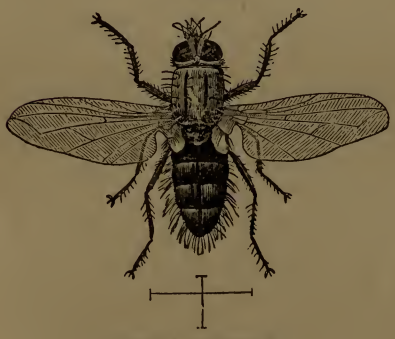
DOTTED-LEGGED PLANT-BUG. — *c*, its beak, enlarged.

prominent tooth pointing toward the head will be noticed. This latter feature is entirely absent in the Plant-bug; while the more slender beak (Fig. 28, *c*), of the latter, the average larger size, the black-dotted legs, and the absence of the opaque brown streak at the transparent and glassy tip of the wing-cases, (*hemelytra*), combine to distinguish still further from its more ferocious relative.

The Dotted-legged Plant-bug was once considered a purely vegetable feeder, and its being caught partaking of carnivorous food is somewhat exceptional, though recorded in my 4th Report, and more recently recorded as new, in *Field and Forest* for Oct. 1876. It is, however, an interesting fact, entomologically considered, and shows that the carnivorous is not so widely separated from the herbivorous habit as we are wont to suppose. Indeed an 8th bug called the Large Green Tree-bug, (*Nezara hilaris*, Say), somewhat resembling *Euschistus* in form, but uniformly green in color, has also been found sucking the juices of our Doryphora larva, though normally it is a plant-feeder.

Ord. *Diptera.*—One of the most efficient, where it occurs, of all the enemies of our Potato-beetle, and the only internal parasite, is what may be called the Doryphora Tachina Parasite, (*Lydella doryphoræ*, Riley). It is a two-winged fly belonging to the parasitic family of Tachina-flies, (*Tachinidæ*). It bears a very close resemblance, both in color and size, to the common house-fly, but is readily distinguished from the latter by its extremely brilliant silver-white face. It may be seen throughout the

[Fig. 29.]



LYDELLA DORYPHORÆ.

summer months flying swiftly from place to place, and deftly alighting on fence or wall, where, basking in the sun, its silvery face shows to good advantage. As with the rest of the family to which it belongs, the habit of the female is to attach a single egg externally to the body of the Potato-beetle larva. This egg subsequently hatches into a little footless maggot, which burrows into the body of its living victim, and eventually destroys it, but not until it has gone underground in the usual manner. The victimized larva, instead of becoming a pupa, and eventually a beetle, as it would have done had it not been attacked, begins to shrink as soon as it enters the ground, and gradually dies; while inside its shriveled skin the parasitic maggot contracts into a hard brown pupa, and in due time issues forth in the shape of the fly which I have figured. This fly has been found at times so abundant in western potato fields, that its buzzing resembled the noise made by a swarm of bees, and the Doryphora was well nigh exterminated by its progeny.

In addition there are in this order certain large Asilus-flies, and notably the Missouri Bee-killer (*Protocanthus Milberti*, Macq), which pounce upon and suck the vitals out of the Doryphora larva. All these large flies are very blood-thirsty — the hawks of the insect-world; and some of them are quite injurious to bees.

[Fig. 30.]

ASILUS-FLY.

Thus, besides one spider and one mite, there are a full two dozen species of true insects, viz.: one wasp, fifteen beetles, six half-wing bugs and two flies, that have been

actually observed by myself and others, preying on the Colorado Potato-beetle. The number has increased from year to year as the insect widened its range, and there will no doubt yet be many predaceous species added to the list.

REMEDIES.

These fall into four different categories. 1st, Encouragement of the natural enemies just referred to; 2nd, Preventive measures; 3rd, Mechanical Means of destruction; 4th, The use of poisonous applications to the plant for the same purpose.

1st.—*Encouragement of Natural Enemies:*—Under this head it is only necessary to draw the reader's attention to those which have been figured and described, and to urge their protection wherever found. More particularly in hunting for the Doryphora eggs early in the season, the farmer should learn to discriminate between them and the similar but invariably smaller eggs of the Ladybirds.

2nd.—*Preventive Measures:*—Something may be done in this line in the Fall by means of heaps or rows of straw, or of the dried potato-haulm, under which some of the beetles will shelter to hibernate, and may be killed in winter. In the Spring, some good may be accomplished by adopting the following plan: Slice some potatoes, dust the pieces with Paris Green, and drop them about a field early in the season when the beetles come from their winter quarters. They feed upon the slices and of course die. The method can only be safely practiced where no domestic animals can get at the baits. Another method is that first employed by Mr. James Rivers, of Cass County, Mich., viz., a mixture of chicken manure and ashes, applied to each hill of potatoes just as the plants are coming through the ground—the object being to check the cracking and raising of the soil, and thus prevent the beetles from hiding around the young plants at night or during cold weather. The application appears in addition

to keep the beetles off, at the same time that it invigorates the plant.

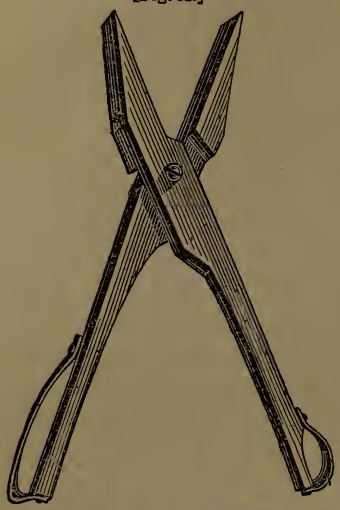
Col. Fred. Hecker, of Summerfield, Ills., once had a patch of potatoes covered with straw, which had entire immunity from the insect's attack; but it is doubtful whether under the same treatment such immunity could always be relied upon. Careful watch should be kept for the eggs that are first deposited. By stooping the body they are easily seen on the underside of the leaves when the plants are young. Thorough cultivation by means of frequent stirring of the soil should be practiced. Early varieties in preference to late ones should be planted, because the insects are usually more numerous late in the season than they are during the Spring and early Summer. The preference should be given to the Peach Blow, Early Rose, and such other varieties as have been found most exempt from attack, and the fields surrounded on the outside by rows of such tender-leaved varieties as the Mercer, Shaker, Pinkeye, and Early Goodrich. The beetles will be attracted to these, and the labor of killing will be facilitated. Above all the potato field should be isolated as much as possible, either by using land surrounded by timber, or by planting in the center of a cornfield. It is well also to plant in ground that was not the previous year used for potatoes.

3rd.—*Mechanical Means of Destruction*:—One of the simplest means of destruction is, of course, hand-picking, and when pursued early in the season, it is most effectual. In doing so it is generally the custom to collect the beetles and larvæ in some vessel of water and afterwards destroy them; but it is perhaps preferable to crush them while on the vines, and for this purpose a very simple pair of pincers, like those represented in Fig. 31, consisting of two pieces of wood, a screw, and two small strips of leather, will be found very useful.

During the Summer of 1870 there was a sudden diminu-

tion of the numbers of this insect throughout the Mississippi Valley, and it did not increase to any alarming extent during the rest of the season. The disappearance was in many sections so thorough that it is very questionable whether man and natural enemies should alone be credited with the cause. The Spring was uncommonly dry and warm, and, so far, was favorable to the increase of the insect; but the summer drouth and extreme heat which followed were quite unfavorable to its multiplication. Warm, dry weather in Spring is congenial to the growth and well-being of the larvæ, as they swarm upon and devour our vines; but at a later stage of their lives, when they have to enter the earth to undergo their transformations, a great many of them will undoubtedly die if the earth continues excessively dry and hot. They will, in short, be dried and baked to death. Those who have had large experience in breeding insects, and who understand the importance of coolness, and especially of moisture, in the successful development of those which transform under ground, feel perfectly warranted in such an inference, even though no systematic and accurate experiments have been made to test its validity. The extreme heat and dryness of the season, furnished a good opportunity to employ the sun-scalding remedy, and it was fully shown that in an intense summer sun, the larvæ and even the beetle will generally die, if knocked from the vines on to the dry and heated ground, especially if

[Fig. 21.]



POTATO-BEETLE PINCERS.

the vines have been well hilled. During hot, dry weather, therefore, especially in the more southern latitudes where the insect ranges, this mode of destruction may be employed to advantage ; but it should not be forgotten that some of the full-grown larvæ will doubtless enter the ground, and that the method can only be employed at a season when the insects have done most of their damage.

A cheap, rapid, and effective method, which commends itself to the good sense of every one, is for one person to go along the rows with a short-handled broom, and by quick motions knock all the bugs off, while a second person follows immediately after, dragging by a single horse a heavy bundle of brush, or close-toothed harrows made for the purpose. Some of the bugs will escape being killed, and a few of the younger larvæ may not be knocked off, but the operation is so rapidly performed that it will bear repetition as often as necessary.

As the ravages of Doryphora became more and more general and destructive, and the necessity for its extermination became correspondingly urgent, the inventive genius of many farmers and gardeners was exercised in devising implements for its destruction, which would do the work more expeditiously and cheaply than it could be done by hand.

One of the first of these was a horse-machine, invented in 1866, by a Mr. Benson, of Muscatine, Iowa. As this machine, or some improvement on it, may prove advantageous where potato-growing is carried on extensively, I subjoin his account of it.

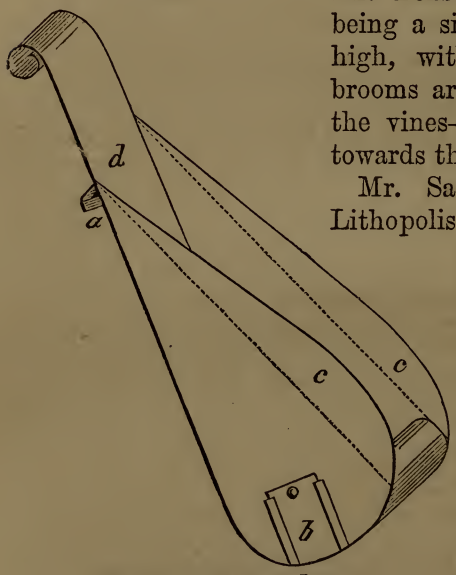
"The cost of the machine was about thirty dollars. It consists of a frame-work, which moves astride the row of potatoes, on which is mounted longitudinally a reel somewhat like the one on McCormick's old Reaper, which knocks the bugs off the plants into a box on one side. This box is of course open on the side next the row nearly down to the ground, but is some two feet high on the outside and at the ends. The reel works over the inner edge

of the box, and the bugs are whipped off the vines pretty clean; and the most of them are thrown against the higher side of the box, which converges like a hopper over two four-inch longitudinal rollers at the bottom, between which the bugs are passed and crushed. These rollers are some three or four feet long.

"Those insects which are perched low down on the plants are frequently knocked on to the ground; but I think they would soon crawl up again; and repeating the operation at intervals would very greatly reduce their numbers, and lessen very much the labor of hand-picking, which I think would be advisable in conjunction with the use of the machine, in order to destroy the eggs and diminish the young brood, which is most destructive to the foliage of the plant."

In 1870 Mr. George Squires, of Montgomery, Ill., built a machine to be drawn by horses, which worked very effectually. It is a modification of the one invented by Mr. Benson, described above, being a simple box, six inches high, with wheels to which brooms are attached to sweep the vines—the wheels circling towards the box.

[Fig. 32.]



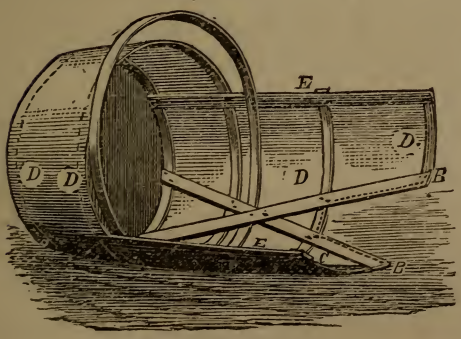
For Collecting the Insect.

Mr. Samuel Creighton, of Lithopolis, Ohio, subsequently invented his "Improved Patent Insect Destroyer," which is especially intended for this insect. It is a hand machine of a very simple nature, and the accompanying outline, (Fig. 32), will give a very good idea of it. In using, it is held in the right hand by the handle, *a*, and placed at one side of the potato hill, with the upper end more or less inclined, according to the size of the plants.

In this position the lower branches of the plants will overhang the forward edge of the plate, *d*, and the flanges of the sides *c*, *c*, which are slightly bent outwards, will embrace the second and third side of the vines, leaving the fourth exposed. The operator then strikes this exposed side, with a light, flat, and broad broom, thus detaching the insects which fall to the bottom of the trap. Whenever the trap is filled the insects are emptied out through a sliding door, *b*, and destroyed in whatever manner the operator sees fit. A good size for this trap is $2'|_3$ feet in hight, 15 inches from flange to flange, and 7 inches across the narrow way of the pocket. It should be made of tin, or if of wood, the pocket should be lined with tin; as when kept smooth or moistened with oil or water the insects can not easily crawl out, as one goes from hill to hill. This contrivance is but an improvement on the common tin pan, and its principal merit lies in its cheapness and simplicity.

Mr. H. Bowen, of Sheridan, Illinois, thus describes an instrument which he has used with ease and profit. It is not patented, and commends itself for lightness and simplicity:

[Fig. 33.]



POTATO-BEETLE CATCHER.

Take four wooden barrel hoops, *D*, *D*, and two narrow barrel staves, two and a half inches wide, *B*, *B*, and two more, *E*, *E*. For the handle use a hoop of sufficient length to be handy for the person that uses it, open it and fasten it to the staves. All these pieces are to be nailed together with small wrought clinch nails. When this is done it will be nearly in the form shown in fig. 33, or

something like a flour-scoop. The frame work is to be covered by sewing on cotton cloth, in the manner shown in the engraving.

To work it, it is held in one hand, and the mouth is slipped around the hill of potatoes close to the ground. With the other hand the vines are struck a light blow with a *new* broom, and all the bugs are jarred into the cage. After a quantity has been "bagged" they are emptied out and destroyed.

There are several other devices, both patented and non-patented, all having the same object in view. Most of them are too complicated to be very practical, and none that I am acquainted with are superior to the few here referred to.

The great difficulty with all mechanical contrivances of this kind, lies in the fact that they can only be used when the vines are of a considerable size, whereas the enemy must be most persistently fought from the moment the ground parts to give way to the sprouting tuber, until the plants are a few inches high.

4th.—*Poisonous Applications to the Plant.*—After the beetle had established itself in the more densely populated States, it soon became evident that neither hand-picking nor more wholesale slaughter by means of mechanical contrivances would enable the potato-grower to cope successfully with his enemy. Many farmers preferred to lose their potato crop rather than to expend the amount of time and labor necessary to secure it, and the pest, in consequence, multiplied to an alarming extent. The discovery of a cheap, easily applied and reliable destructive agent became all important, and to this end numerous experiments were made by the writer, in 1869, with various poisonous and acrid substances, among which were lime, ashes, cobalt, white hellebore, cresylic acid, soap, and arsenic. Some of these produced no effect whatever upon the insects, while others in killing the pests killed the potato-vines as well, and were therefore rejected as impracticable. Paris green, as it was first

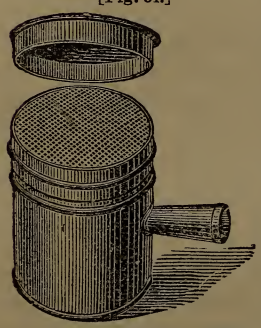
used, without any admixture, was likewise fatal to the vines; but the discovery was soon made that when combined with certain proportions of flour or plaster, and applied while the dew was on, the insects were killed without any deleterious effects being produced upon the plants. This substance has now become THE remedy for the Colorado Potato-beetle, and it is the best yet discovered. Having thoroughly tested it myself, and having seen it extensively used, I can freely say that, when applied judiciously, it is efficient and harmless. If used pure and too abundantly, it will kill the vines as effectually as would the bugs, for it is nothing but arsenite of copper (often called "Scheele's green" by druggists), and contains a varied proportion of arsenious acid, according to its quality—often as much as fifty-nine per cent., according to Brande & Taylor. But when diluted with from 15 to 20, or if the green be absolutely pure, with 25 to 30, times its weight of flour, it causes no injury to the foliage, and just as effectually kills the insects. The varied success attending its use, as reported through our many agricultural papers, must be attributed to the difference in the quality of the drug. The adhesive property of flour—which may be of the most inferior quality—gives it an advantage over ashes, plaster, and slacked lime, although these may have the advantage of cheapness and are frequently used. The green cannot well be mixed with the other substances, except by the aid of a mill, and it is for this reason that those who mix in large quantities have the advantage.

Paris green is now also used to a considerable extent in liquid suspension, in proportion of one tablespoonful of pure green to a bucketful of water. The liquid has the advantage over the powder, in that there is less danger from injury in its use, and that it can be effectually used at any time of day; while the powder can be employed to advantage only while the dew is on the plants. It has,

however, some disadvantages : 1st, the green is not soluble, for though it quickly gives a green tint to the water when stirred, it soon settles to the bottom, unless kept in suspension by continued stirring or agitation ; 2nd, it settles in spots on the leaves, the natural tendency of the water, in finding its level, being to carry and concentrate it wherever a drop finds rest and evaporates ; 3rd, too much is usually wasted on the ground in the sprinkling. I have, therefore, found it much more convenient, on a small scale, to use the powder, where it can be obtained ready mixed by machinery. Applied when the dew is on the plants it will adhere more uniformly, and it obviates the necessity of carrying about so much water.

But whether the green be used in water or as a powder, the flour will prove a desirable addition, since it renders the green more adhesive and consequently more serviceable. Some care will be required in using, however, to prevent its forming lumps. The adhesive quality in the liquid may also be obtained by dissolving molasses, dextrine, or gum arabic in the water—the two latter, however, much more expensive than the flour. The green in the form of powder may be shaken over the vines in various manners, and some persons have found an old sleazy sack, such as those used for table salt, to do good service, when attached to the end of a stick. It is most safely applied by the aid of a perforated tin box with a double lid for safety when not in use (Fig. 34), and attached to the end of a stick three or four feet long. The least possible dusting suffices, and by taking the handle of the dust-box in the left hand, and then tapping the box with a stick held in the right hand, one can walk rapidly along and regulate the amount sifted.

[Fig. 34.]



Dust-box for Paris green, *Upside-down.*

In the form of liquid the green may be sprinkled over the vines with a sprinkler or an old broom. This will serve on a small scale, but for large fields various contrivances have been successfully employed to save time and labor.

In 1874 Mr. Frank M. Gray, of Jefferson, Cook county, Ills., sent me a sprinkler which he has constructed for sprinkling two rows at once. It is so simple and yet so useful that a brief description of it will not be out of place here. It consists of a can capable of holding about eight gallons of liquid, and so formed as to rest easy on the back, to which it is fastened, knapsack-fashion, by adjustable straps, which reach over the shoulders and fasten across the breast. To the lower part of the can are attached two rubber tubes, which are connected with two nozzles on sprinklers. The inside of the can has three shelves, which help to keep the mixture stirred. There is a convenient lever at the bottom which presses the tubes and shuts off the outflow at will, and two hooks on the sides near the top on which to hang the tubes

[Fig. 35.]

GRAY'S IMPROVED SPRINKLER, FOR THE USE OF PARIS GREEN WATER.

when not in use. On the top is a small air-tube and a capped orifice. Two bucketfuls of water are first poured into the can, then three tablespoonfuls of good green, well mixed with another half-bucketful of water and strained through a funnel-shaped strainer which accompanies the machine, and the use of which prevents the larger particles of the green from getting into the can and clogging up the sprinklers. Five to eight acres a day can readily be sprinkled by one man using the can, and from one to one and a half pound of good green, according to the size of the plants, will suffice to the acre. Two lengths of nozzles are furnished, one for use when the plants are small, the other when they are larger. The can should be filled on the ground and then raised on a bench or barrel, from which it is easily attached to the back. The walking serves to keep the green well shaken, and the flow of the liquid is regulated at will by the pressure of the fingers on the tubes at their junction with the metallic nozzles. When not in use, the tubes should be removed, the can emptied, and laid on its back. I can testify to the ease and efficiency with which this little machine may be used.

An excellent Spray Machine has been invented by Mr. W. P. Peck, of West Grove, Pa., consisting of a tank, strapped knapsack-fashion on the shoulders, and connected by rubber tubes with a pair of bellows, strapped to the waist, turned by a crank, and connected with a movable nozzle. I have used it with good results, and know of no instrument that better answers the purpose, or more effectually economizes material. This atomizer can of course be used to distribute other liquids than Paris green water, and to protect other plants than potatoes; but for use in the potato field it answers an admirable purpose. The tank holds three gallons, and there is a simple device at the bottom which, by the motion of walking, keeps the liquid in agitation and prevents the green

from settling. The liquid issues in a fine spray and with considerable force. The very general use of Paris green as an insecticide had the effect at first to raise the price of the drug to an exorbitant figure, and in many places the demand largely exceeded the supply. The impetus given to its manufacture, however, soon reduced it to a

[Fig. 36.]

PECK'S SPRAY MACHINE.

reasonable price again, and of late years the cost of its use to protect a potato-field, even where the insect has been very abundant, has averaged only from $3 to $5 per acre, according to the number of applications.

In addition to Paris green, a great number of drugs and other substances have been tested as "Potato-bug" remedies. The most thorough experiments were instituted

during the summer of 1871, by Messrs. Wm. Saunders and E. B. Reed, of London, Ont., under the direction of their Commissioner of Agriculture, and from their report I quote the results obtained with various chemicals :

Arsenious Acid (Arsenic).—This chemical, being much cheaper than *Paris Green*, and more uniform in its composition, we hoped would have proved a practical and safe remedy. We tried it in the proportions of half ounce, one ounce, and two ounces, to a pound of flour, and while we are not prepared, from the few trials we have made, to entirely disapprove of its use, the results we have obtained point to the conclusion that where it has been used in sufficiently large proportions to destroy the insect, it has caused more or less injury to the leaves. In cases where *Paris Green* is not obtainable this might be used as a substitute, in the proportion of one ounce to one pound of flour, which should always be colored with some black powder, such as charcoal or black antimony, so as to lessen the risk of accident from its use.

Another Arsenical compound was also tested, known in commerce as *Powdered Cobalt* or Fly Poison; this was used in the same proportions as the last mentioned, and with similar results, but owing to its higher price we do not recommend it for general use.

Sulphate of Copper (Blue Stone).—A strong solution of this salt was tried in the proportion of two ounces to one gallon of water, and showered on the vines with a watering pot, without damage to either the insect or the plant.

Bichromate of Potash.—This is a poisonous substance largely used in dyeing, and one which has attracted some attention in France of late, as a remedy for insects. We used it dissolved in water in the proportion of two ounces to three gallons of water. This killed the insects effectually, but at the same time destroyed the plants. Whether, in a more diluted form, this remedy could be effectively used without injury to the foliage, we are unable to say, but shall experiment further with it.

Powdered Hellebore.—This powerful irritant, which is so effectual as a remedy for the *Currant Worm*, we tried without perceptible effect, both in powder and also mixed with water, in the proportion of one ounce to the gallon of water. Several other poisonous substances were also used with like results.

Carbolate of Lime.—There are several preparations sold under this name, which we found to vary much in composition and character, and equally so in effect. We tried an article known

as Dougall's without any good results, but succeeded better with one prepared by Lyman Bros., of Toronto, a black powder manufactured, we understand, from coal tar. This destroyed a large proportion of the larvæ, but we doubt whether it would kill the perfect insect; it is, moreover, used in an undiluted form, which would render its cost greater than that of the *Paris Green* mixture, so we see no advantage in using it, although the fact of its being less poisonous may induce some to try it who are prejudiced against *Paris Green.*

Ashes and Air-slacked Lime, we found, had been extensively used by many of the farmers on the frontier districts, but, so far as we could see or learn, without any perceptible results.

Decoctions of Elder leaves, Dog-fennel, the roots of the Mandrake or May Apple, (*Podophyllum peltatum*), black-pepper, ashes, lime, and a variety of other applications have been recommended. Many of the proposed remedies are simply ridiculous, while some are partially effective. Both lime and urine or uric acid have been used with good effect, but do not compare to Paris green.

A correspondent of the *Prairie Farmer,* for July 3, 1875, in whose signature —"T. of Iowa"—I recognize an old friend and intelligent observer, gives the following experience:

I have had quite as good success in using the ingredients from which the green is made, as from the finished article, bought in paint and drug shops at 50 cents a pound, especially when the local demand is so great that it cannot be bought at all. The following directions for making it are taken from Brande's Chemistry: Dissolve two pounds of sulphate of copper, blue vitriol, (costing 20 cents per lb., or 40 cents), in a gallon of hot water, keeping it in a stone jar. Dissolve in another large jar, one pound of white arsenic, (costing 10 cents), and two pounds of saleratus or pearl ash, (cost 20 cents), in forty-four pounds of hot water, stirring well, until thoroughly dissolved. These articles, costing 75 cents, will make about five pounds of Paris green, costing $2.50. I usually keep them in solution and mix in the proper proportions, one part of the first to five of the latter, as they are needed. The green immediately begins to precipitate in a fine powder, and is much more convenient for use, in solution, than the dry article sold in the shops.

Before leaving this subject of poisonous applications, it may be well to say a few words about two other compounds that have been strongly recommended and advertised as such. One of these is advertised as "Potato Pest Poison," by the Lodi Chemical Works of Lodi, N. J. It is put up in pound packages, which are sold at $1 each, with directions to dissolve four ounces in two quarts of hot water, then pour into a barrel containing thirty gallons of cold water, and use on the vines in as fine a spray as possible. Analysis shows it to be composed of one part of pure salt and one part of arsenic (arseniate of soda), and it has the general color and appearance of common salt. I had this poison tested in a field of late potatoes, which had been badly infested during the Summer, but of which about half the vines had been saved by pretty constant hand-picking. These were at the time fairly covered with the insect in the egg, larva, and beetle states. Five rows where treated with the poison, both according to directions and by finely sprinkling the dry powder over the vines. As soon as the powder touched the larvæ, they writhed and became restless, as with pain, the powder dissolved and formed a translucent coating upon them, and in about three hours they began to die. The beetles were not so easily affected, though they too were in time killed by it. Used as directed, it destroys, but hardly as efficiently as the ordinary Paris green mixture. A pound of Paris green, costing much less than a pound of the Lodi poison, will go nearly as far in protecting a field of potatoes, and I cannot see any advantage to the farmer from the employment of a patent poisonous compound, of the nature of which he is ignorant, when a cheaper one is at hand. The color of the Lodi poison is also very objectionable, as there is much more danger in the use of poisons, when their color renders them undistinguishable from ordinary salt. The second is a patent "pest poison," gotten up by the Kearney Chemical

Works, N. Y., and extensively advertised for this particular insect. It is a prototype of the preceding, consisting of arsenate of sodium and common salt, faintly colored with rosaniline, and it acts in a similar manner. It is put up in a $^1|_2$ lb. package, for 50c., which is to be dissolved in 60 gallons of water, and all that has been said of the Lodi poison is true of it.

THE USE OF PARIS GREEN.

As this mineral has now come into general use for the Colorado Potato-beetle, and likewise for the Cotton Worm and various other insects; and as it is a virulent poison, the question as to its safety for the purpose here recommended is a very important one. It was my lot to be largely instrumental in causing its now general use for the two insects mentioned, and the position which I took from the first has been justified by the facts, which are herewith presented, and which will serve to dissipate much misapprehension.

Past Experience.—In the early history of the use of this mineral as an insecticide, most persons, myself included, were loth, on theoretical grounds, to recommend its general use; and I have ever insisted that the many other mechanical and preventive measures, which, if persistently employed, are sufficient to defeat the foe, should be resorted to in preference. But the more diluted form and improved methods now-a-days employed in using the poison, render it a much safer remedy than it was a few years back; and no one should fail to take into account that during the past seven or eight years, millions of bushels of potatoes have been raised, the leaves of which have been most thoroughly sprinkled with the Paris green mixture, without any injurious effect to the tuber, or to persons using potatoes raised in this manner. Indeed, scarcely any potatoes have been raised in the Middle States during these years, without its use; yet I have to

learn of the first authentic case of poisoning or injury whatever, except through carelessness and exposure to its direct influence. So far as experience goes, therefore, there is nothing to fear from the judicious use of the mineral. Let us then consider, from the best authority, what are the effects of its use as at present recommended: First, on the plant itself; second, on the soil; third, on man, indirectly, either through the soil or through the plant.

Its Influence on the Plant.—Practically the effect of sprinkling a plant with Paris green, will depend very much on the amount used and on the character of the plant treated. Thus, from experiments which I made in 1872, a thorough coating of a mixture of one part of green to fifteen of flour, while injuring some of the leaves of peas, clover, and sassafras, had no injurious effect on young oaks, maples, and hickories, or on cabbage and strawberries; while the fact has long been known that when used too strong and copiously it destroys potato vines. It is for this reason that the experiments that were made in 1874 on beets, by a committee appointed by the Potomac Fruit Grower's Society, are of little value, as against the universal experience of the farmers of the Mississippi Valley. The mixture used by the committee, and which they call "highly diluted," consisted of one part of green with but six of the dilutent, instead of from twenty-five to thirty parts of the latter; and it is no wonder that, as reported by the committee, the vitality of the plant was seriously impaired. There can be no question, therefore, about the injurious effect of the green upon potato vines, when it is used pure or but slightly diluted; yet in this case, since it is the office of the leaves to expire rather than inspire, we cannot say that the plant is injured, or killed by absorption, any more than if it were killed by hot water, which, according to the degree to which it is heated, or the copiousness of

the application, may either be used with impunity or with fatal effects. Indeed, judging from my own experience, I very much incline to believe that future careful experiments will show that injury to the leaf by the application of this compound, arises more often from the stoppage of the stomata, which is effected as much by the diluent as by the arsenite itself. So much for the influence of the poison when coming in contact with the plant above ground. The question as to how it affects the plant below ground, through the roots, may be considered in connection with—

Its Influence on the Soil.—As Prof. S. W. Johnson, in an able review of the subject, stated two years ago : * "One pound of pure Paris green contains about ten ounces of white arsenic, and about four ounces of copper;" or, to state it in the usual way, Schweinfurt or *pure* Paris green contains fifty-eight per cent. of arsenious acid. One pound of the green uniformly spread over an acre of soil, would amount to sixteen-hundredths of a grain per square foot, or nine-hundredths of a grain of arsenious acid. If uniformly mixed with the soil to the depth of a foot, it would, of course, be the same to the cubic foot. In actual practice, even this amount does not reach the soil direct or in an unchanged form, since much of it is acted upon by the digestive organs of the fated insects. It is safe to say that even if the green retained for all time its poisonous power and purity in the soil, this mere fractional part of a grain might be added annually for half a century without any serious effects to the plants. In reality, however, there is no reason to believe that it does so remain. Of the few experiments on record which bear on this point, those made by Prof. R. C. Kedzie, of the Michigan Agricultural College, in 1872, are most interesting and instructive. In a paper read before the Natural History Society of the College, he

* New York Tribune, December 16, 1874.

proved, from these experiments, that where water was charged with carbonic acid or ammonia, a certain portion of the green was dissolved, but was quickly converted into an insoluble and harmless precipitate with the oxide of iron which exists very generally in soils. Fleck has shown (Zeitschrift für Biologie, Bd. viii, s. 455, 1872), that arsenious acid in contact with moist organic substances, especially starch sizing, forms arseniuretted hydrogen, which diffuses in the air, and it is more than probable that the green used in our fields will lose its poisonous power, and disappear in these and other ways. The question as to how the plant is affected by the poison through the soil is, therefore, partly answered by the above facts. Water is both the universal solvent and the vehicle by which all plants appropriate their nourishment; but in this instance its solvent and carrying power is for the most part neutralized by the oxide of iron in the soil; and though some experiments by Dr. E. W. Davy, and quoted by Prof. Johnson in the article already cited, would indicate that, under certain circumstances, some of the arsenious acid may be taken up by plants before passing into the insoluble combination; yet the quantity is evidently very slight.

Moreover, all doubt as to the danger to the tuber, to the soil, or to man, indirectly, was set at rest, by a further series of thorough experiments made by Prof. Kedzie in 1875, from which he concludes: 1st, Paris green that has been four months in the soil no longer remains as such, but has passed in some less soluble state, and is unaffected by the ordinary solvents of the soil. 2nd, When applied in small quantities, such as alone are necessary in destroying injurious insects, it does not affect the health of the plant. 3rd, The power of the soil to hold arsenious acid and arsenites in insoluble form, will prevent water from becoming poisoned, unless the green is used in excess of any requirement as an insecticide.

These experiments of Prof. Kedzie's accord, so far as they refer to the influence of Paris green on man through the plants, with others by Prof. McMurtrie, of the Department of Agriculture, which showed that even where the green was applied to the soil in such quantities as to cause the wilting or death of the plants, the most rigorous chemical analysis could detect no trace of arsenic in the composition of the plants themselves.

Some persons have imagined that the soggy and watery potatoes that have been so common of late years, are due to the influence of this poison ; but this idea is proved to be erroneous by the fact that such imperfect potatoes are not confined to the districts were Paris green has been used. Indeed, they are much more likely due to the injury and defoliation of the plant by the insect ; for no plant can mature a healthy tuber when its leaf system is so seriously impaired by the constant gnawings of insects. Finally we must not forget that both arsenic and copper are widely distributed throughout the inorganic world* and are found naturally in many plants ; and so far from injuring plants, in minute quantities, arsenic occurs in the best superphosphates and the volcanic soil around Naples, which, like all volcanic soils, contains an unusual amount of it, has the reputation of being a specific against

* Prof. Johnson, (*loc. cit.*) writes:

"The wide distribution of both arsenic and copper is well known to mineralogists and chemists. These metals are dissolved in the waters of many famous mineral springs, as those of Vichy and Wiesbaden. Prof. Hardin found in the Rockbridge Alum Springs of Virginia, arsenic, antimony, lead, copper, zinc, cobalt, nickel, manganese, and iron. The arsenic, however, was present in exceedingly minute quantity. Even river water, as that of the Nile, contains an appreciable quantity of arsenic. Dr. Will, the successor of Liebig, at Giessen, proved the existence of five poisonous metals in the water of the celebrated mineral springs of Rippoldsau, in Baden. In the Joseph's Spring he found to 10,000,000 parts of water, arsenic (white), 6 parts ; tin oxide 1-4 part ; antimony oxide, 1-6 part ; lead oxide, 1-4 part ; copper oxide, 1 part. Arsenic and copper have been found in a multitude of iron ores, in the sediments of chalybeate springs, in clays, marls and cultivated soils. But we do not hear that the arsenic thus widely distributed in waters and soils ever accumulates in plant or animal to a deleterious extent."

fungus diseases in plants. A certain quantity may therefore be beneficial to plants, as it appears to be to animals, since horses fed on a grain or two a day are said to thrive and grow fat.

Its Influence on Man indirectly through the Soil or through the Plant.—The green as now used could not well collect in sufficient quantities to be directly deleterious to man in the field in any imaginary way, and this statement is borne out by Prof. Kedzie's experiments; while its injury through the plant is, I think, out of the question; for the plant could not absorb enough without being killed. The idea that the earth is being sown with death by those who fight the Colorado Potato-beetle with this mineral, may, therefore, be dismissed as a pure phantasmagoria.

In conclusion, while no one denies the danger attending the careless use of Paris green, and all who have recommended its use have not hesitated to caution against such carelessness, a careful inquiry into the facts from the experimental side bears out the results of a long and extensive experience among the farmers of the country —viz: that there is no present or future danger from its judicious use, in the diluted form, whether as liquid or powder, in which it is now universally recommended. It is in this as in so many other things, a proper use of the poison has proved, and will prove in future, a great blessing to the country, where its abuse can only be followed by evil consequences. Poison is only a relative term, and that which is most virulent in large quantities is oftentimes harmless or even beneficial to animal economy in smaller amounts. The farmers will look forward with intense interest to the work of the committee appointed by the National Academy, or of any national commission appointed to investigate the subject, and will hail with joy and gratitude any less dangerous remedy that will prove as effectual; but until that is discovered,

they will continue to use that which has saved them so much labor and given so much satisfaction. I would therefore say to those agriculturists of the East who are in any way alarmed by what has been written on this subject, and who hesitate to use the Paris green mixture—profit by the experience of your more western brethren, and do not allow the voracious Doryphora to destroy your potatoes when so simple and cheap a remedy is at hand.

In case of direct poisoning from carelessness or whatever cause, it will be well to state here that the antidote for Paris green poison is hydrated sesquioxide of iron. Nearly every druggist keeps it always on hand. If it can not be bought, it may be prepared thus : Dissolve copperas in hot water, keep warm, and add nitric acid until the solution becomes yellow ; then pour in ammonia water—common hartshorn—or a solution of carbonate of ammonia, until a brown precipitate falls. Keep this precipitate moist and in a tightly corked bottle. A few spoonfuls taken soon after even a bad case of poisoning with Paris green or arsenic is a perfect remedy.

BOGUS EXPERIMENTS.

It was once reported to me that a neighbor had succeeded in driving away all his potato bugs by strewing elder branches among the vines. I went to examine the field and found my friend enthusiastic over his discovery; and indeed though the vines were nearly devoured, there were but a few full grown larvæ to be found. But, as he could not tell us what had become of the "slugs," I undertook to show him where they had gone, and after digging a few moments with a trowel, unearthed dozens of them, the majority in the pupa, but a few yet in the larva state. He had, in fact, been misled by appearances, for want of better knowledge of his enemy. The larvæ as they acquired their growth suddenly became so destructive, that to save his vines he was obliged to try some

means of killing them, and as an experiment he tried the elder. The larvæ were just ready to disappear of their own accord, and as the great bulk of them did really disappear in two or three days after the application, the apparently logical inference was made that they had been driven away by the smell of the elder.

How many of the published remedies that flood the country owe their origin to just such defective proof

ALARM ABOUT THE INSECT ABROAD.

In 1871, speaking of the eastward march of this insect, I wrote as follows: "Indeed, it is quite possible that even the broad Atlantic may not stay its course; but that when once the beetles swarm in the streets of New York as they did in those of St. Louis last spring, some female, loaded with fertile eggs, and hidden in the nooks and crannies of some vessel, may be safely borne over to the land of 'murphies,' where she might easily found a colony which would soon spread consternation into other potato-growing countries to the eastward. In giving, through Sir Walter Raleigh, the precious tuber to Europe, America conferred upon the Old World an everlasting boon. She may yet unwittingly be the means of bequeathing as great a bane, by sending across the ocean the deadliest enemy of that tuber! At all events, it behooves our European neighbors to be on the look-out, and to prevent, if possible, any such catastrophe."

In December, 1872, Col. Fred. Hecker, of Summerfield, Illinois, the well-known and enthusiastic political agitator and tribune, sent to the *Gartenlaube* (Heft 3, 1873,) an article on this insect. The article was a condensation, and in some parts a literal translation from my Reports, my figures being copied to illustrate it. It was afterwards re-translated and the illustrations re-copied (and accuracy is not apt to increase with these processes, and certainly did not in these instances), for several

English journals, over the signature "*Fr. H., State of Illinois.*" Some of the articles in the English periodicals on this "new enemy of the potato" close with the advice that "in the importation of seed of American potatoes, which is now carried on to a very large extent, the utmost caution should be exercised to prevent the introduction of the beetle to this country."

Indeed, Mr. J. Algernon Clarke, Secretary of the Central Chamber of Agriculture, on the 10th of February, 1874, addressed a letter to Mr. Gladstone, calling his attention to the imminent risk to which the United Kingdom, especially Ireland, is exposed, and went so far as to suggest that the importation of potatoes from the United States and British America should at once be prohibited.

In 1874 the governments of Belgium, France, Switzerland and Germany prohibited the importation of American potatoes, and Italy, the Netherlands, and Great Britain, which had been urgently solicited to follow their example, began seriously inquiring into the necessities of the case.

The British Government was naturally slow to take such stringent steps, which would more deeply affect it than the other nations mentioned, since Great Britain does the larger trade in American potatoes. In reply to Mr. Herbert, M. P., for Kerry, who asked the Chief Secretary for Ireland, whether Her Majesty's government had taken any steps to prevent the introduction of the insect, Sir M. M. Beach sought to abate fear, rather underrated the danger, and wisely concluded that any interference with the trade, should first have the most careful consideration. Those who had watched the insect's gradual spread during the past seventeen or eighteen years, from its native Rocky Mountain Home to the Atlantic ; and had seen how the lakes, instead of hindering its march into Canada, really accelerated that march by affording carriage on vessels, rafters, and other floating objects, could have no

doubt that there was cause for the danger felt by our transatlantic friends.

Yet the opinion had been repeatedly expressed by the writer—and very generally coincided in by all who had any familiarity with the insect's economy—that when it made its advent into Europe it would most likely be carried in the perfect beetle state on some vessel plying between the two continents. For while the beetle, especially in the non-growing season, will live for months without food, the larva would perish in a few days without fresh potato tops, and would, I believe, starve to death in the midst of a barrel of potatoes, even if it could get there without being crushed; for while it so voraciously devours the leaves it will not touch the tubers. The eggs, which are quite soft and easily crushed, could, of course, only be carried over on the haulm or on the living plant; and while there is a bare possibility of the insect's transmission in this way, there is little probability of it, since the plants are not objects of commercial exchange, and the haulm, on account of its liability to rot, is not, so far as I can learn, used to any extent in packing. Besides, potatoes are mostly exported during that part of the year when there are neither eggs, larvæ, nor potato vines in existence, in the United States. There is only one other possible way of transmission, and that is in sufficiently large lumps of earth, either as larva, pupa, or beetle. Now, if the American dealers be required to carefully avoid the use of the haulm or shaw, and to ship none but clean potatoes, as free as possible from earth, the insect's transmission among the tubers will be rendered impossible; and when such precautions are so easily taken there can be no advantage in the absolute prohibition of the traffic in American potatoes. As well prohibit traffic in a dozen other commodities, in many of which the insect is as likely to be taken over, as in potatoes, and in some of which it is even more likely to be

transported. The course recently adopted by the German government in accordance with the suggestion made in my 6th Report, is much more rational, and will prove a much better safeguard : It is to furnish vessels plying between the two countries with cards giving illustrated descriptions of the insect in all stages, with the request that passengers and crew destroy any stray specimens that may be found. England and Ireland, together with the other European governments, should co-operate with Germany in this plan, and have such a card posted in the warehouses of seaport towns, and the meeting rooms of agricultural societies ; and a possible evil will be much more likely avoided.

While some Europeans have thus been unduly alarmed, and inclined to take proscriptive measures to prevent the insect's introduction, others have ridiculed the idea that the insect could get to Europe, one of them declaring that there is no more danger of the insect's chance transportation than of that of our rattlesnake. Considering that half the weeds of American agriculture, and a large proportion of her worst insect pests, including two beetles—viz : the Asparagus Beetle (*Crioceris asparagi*,) and the Elm Leaf-beetle, (*Galeruca calmariensis*)—in the very same family as our Doryphora, have been imported among us from Europe, there would seem poor foundation for such argument. Moreover, a number of other insects—among them some beetles—of less importance, may be included in the number of importations ; and the Rape Butterfly (*Pieris rapæ*,) whose progress westward has been simultaneous with the Doryphora's eastward, and whose importation dates back but a few years, gives proof of the fact that insects more delicate and with fewer chances of transport than Doryphora, may succeed in getting alive from one country to the other, and in gaining a foothold in the new home. Indeed, the reported occurrence last summer of a living beetle in the Bremen docks, in a

cargo just from New York, is the best evidence ; it effectually sets at rest the arguments alluded to, and bears out the views I have on several occasions expressed as to the possibility of the beetles being carried over in vessels.

It is argued by others that on the continent of Europe our Doryphora would not thrive if introduced, and in a recent letter received from M. Oswald de Kerchove, of Gand, Belgium, author of an interesting pamphlet on the insect,* that gentleman says : "I do not think that the Doryphora, awakened by our early warm weather, could resist the effects of the late cold which we are apt to have in these European countries." The idea that the climate of North America is less extreme than that of Europe is rather novel to us of the cisatlantic ; and from a sufficiently long residence in England, France, and Germany, I am decidedly of the opinion that they delude themselves who suppose that Doryphora could not thrive in the greater part of Europe ; and that to abandon all precautionary measures against its introduction on such grounds would be the hight of folly. An insect which has spread from the high table lands of the Rocky Mountains across the Mississippi Valley to the Atlantic, and that flourishes alike in the States of Minnesota, Wisconsin, Upper Canada, and Maine ; and in Maryland, Virginia and Texas—in fact, wherever the potato succeeds—will not likely be discomfited in the potato-growing districts of Europe.

The more serious and weighty reasons against the possibility of acclimatization, have been urged by H. W. Bates, F. L. S., in a Memoir, published in 1875, in the Journal of the Royal Agricultural Society of England, (Vol. XI, Part II). He argues firstly, that no American beetle has been acclimated in Europe, though several European species are known to have been in America ;

* *L'Ennemi de la Pomme de Terre*, etc., Bruxelles, 1875.

secondly, that the group to which Doryphora belongs is not represented in Europe, and is remarkably restricted to elevated plateaux in the interior of this continent, and range toward the tropics rather than toward the north; thirdly, that the insect has not passed west of the dividing ridge of the Rocky Mountains, or got foothold on the Pacific Coast, which in climate more nearly resembles Western Europe.

Mr. Bates lays some stress on the fact that few American plants and insects have been acclimated in Europe, citing only the Common Water Weed, (*Anacharis Canadensis*), which has spread through their ponds and canals, and the Grape Phylloxera, which has done so much injury to French vineyards. He also says that no American beetle has become acclimated. While it is true that we have received many more species than we have given, enough more of our insects and plants have established themselves there to weaken the force of the objection. The Horse Weed, (*Erigeron Canadense*), and the Grape Mildew, (*Oidium Tuckeri*), may be added to the plants; our common White Ant, (*Termes flavipes*), has done much damage in some parts of Germany; the Woolly Aphis, or American Blight, (*Eriosoma pyri*), is quite a pest in England and on the Continent; a minute yellow ant, (*Myrmica molesta*), which so annoys our housekeepers, has, according to Fr. Smith, been naturalized, and is very troublesome in England; while at least two of our beetles, viz., the Pea Weevil, (*Bruchus pisi*), and the American Meal Worm, (*Tenebrio obscurus*), have been naturalized in Europe—the former doing some damage in S. France; the latter being quite widespread and now sent back in about equal numbers with the European Meal Worm, (*Tenebrio molitor*), by those who make a business of rearing the worms for bird fanciers.

There is some force in all these arguments, but Mr. Bates does not sufficiently appreciate the exceptional

adaptive and migrating powers which the species has exhibited. There are hundreds of N. American insects—and some of the most injurious too—which no one fears will ever reach Europe or establish themselves there, because they are restricted, and have for years been restricted to certain geographical areas. They have exhibited no especial powers of adaptation to new conditions. But our Potato-beetle forms one of those exceptional cases mentioned in the introduction. We mark and note the exceptional vitality though we cannot give a reason for it. Why has *Doryphora* 10-*lineata* overrun the country and become such a pest while its scarcely distinguishable congener, *Doryphora juncta*, feeding on the same genus of plants, has proved incapable of that adaptation, and remained harmless ? Whatever the reason, the fact weakens the force of all generalizations based on geographical distribution. The reasons why the species has not passed west of the Rocky Mountains, find, also, their best explanation in the facts already mentioned in considering the causes which limit its spread.

The possibility of its importation alive is now established. I must think, with the facts before me, that the possibility of its acclimatization is equally great, especially in South Europe. That it would also hold its own in England and Ireland I have not much doubt. It will rather enjoy the more temperate climate ; for while it thrives best during comparatively dry seasons, both excessive heat and drouth, as well as excessive wet, are prejudicial to it. Let us hope that it never will become established in Europe, but that a sufficient knowledge of it will be desseminated there to cause the speedy detection and extermination of the few that may from time to time be carried over. Let the Europeans not neglect precautionary watchfulness, however, by virtue of the arguments of those who believe that the insect could not stand their climate—lest they some day learn to their sorrow that

they have needlessly underrated our Doryphora's toughness of constitution.

NOMENCLATURE.

The insect was first popularly designated as the "Ten-striped Spearman," which is a translation of its technical name. That term has, however, been superceded by the name employed in this work, not because it was numerous in Colorado, but because it was first found there by entomologists long before it had advanced to any of the States to the East. There are hundreds of insects that in like manner take their name from some particular district where first discovered, though they often afterwards prove to be far more common in other districts.

Of course the American reader need not be informed of the fact that the insect has been universally known, since it attained popular notoriety, by the scientific name of *Doryphora* 10-*lineata*, Say. American coleopterists have from the first been fully aware that it differed from the typical genus *Doryphora*, in lacking the point produced on the mesosternum (middle of breast), which is characteristic of that genus as defined by its founder, Olivier. Yet as this character is of secondary importance, and by no means of generic value, in many other families of Coleoptera, and as our insect in other characters, and especially in the short and transverse form of the maxillary palpi, approaches nearer to the genus *Doryphora* than to any other genus of the sub-family, (*Chrysomelides*), the father of American Entomology, Thomas Say, described it under that genus. Subsequent American authorities, including Dr. LeConte, have followed this enlarged definition of the genus *Doryphora*, considering the palpial of much more value than the sternal characters; and Say's name has consequently been universally adopted in this country both by popular and technical writers. The genus *Chrysomela* of Linnæus has been made the basis of

several minor divisions, which are considered to be of generic value or not, according to the opinions of different systematists. Thus Melsheimer in his catalogue of N. A. Coleoptera (1853) refers our Potato-beetle to the genus *Polygramma*, erected by the French entomologist Chevrolat, upon unimportant colorational characters. Subsequently, the Sweedish entomologist Stäl, in a Monograph of the American Chrysomelides,* erected the genus *Myocorina*† on the slightly compressed form of the antennal club, for our Potato-beetle, and several other species from Texas and Mexico, while still later *Leptinotarsa*‡ was proposed by the same author. Until some yet distant day when the science of entomology shall be perfected, there will be a constant chopping and changing in generic nomenclature, (much of it of questionable warrant or advantage), and it is oftentimes preferable, especially in popular works, to anchor to the more comprehensive and better known generic terms, instead of confounding the reader by the more recent changes. There is nothing to prevent any author from erecting new genera, but whether a proposed genus is in the end by common consent adopted or not will depend on the value of the characters on which it is founded. Our best authorities ignore the more recent divisions, and LeConte writes me: "Let us set our faces against the adoption of the multi-

* Trans. Sweedish Academy, 1858, p. 316.

† *Myocoryna* was already used by Déjean in the same Family.

‡ An examination which I was permitted to make in 1875 of the admirable and extensive collection of Chrysomelidæ belonging to Mr. H. W. Bates, of London, shows that the tibial groove on which Stäl founds his new genus *Leptinotarsa*, to which our Potato-beetle is referred, and under which it is published in Gemminger and Harold's Catalogue, is really of no generic value. Several genuine Doryphoræ with the sternal spine fully developed have it in varying degree, and in *concatenata*, (Fabr.) it is even more conspicuous than in 10-*lineata*. I fully agree with Dr. LeConte, that if any character has value in separating 10-*lineata*, it is the form of the palpi which ally it more to *Doryphora* than to *Chrysomela*, and make of it, with a few others, a natural group in that genus, distinguished by peculiar coloration and want of development of the sternal spine.

tude of genera, which even the founders fail to sustain. * * * Let *Polygramma, Leptinotarsa, Myocoryna,* etc., never be mentioned amongst us." Thence, if we write *Chrysomela* 10-*lineata* (Say), with Crotch, in his list of N. A. Coleoptera (1873), we indicate that in our opinion the later divisions into which that genus has been broken up, and which would include this species, are not based on sufficiently important and distinctive characters; if we write *Doryphora* 10-*lineata,* Say, we express our belief in the generic value of the palpial characters. In either event no confusion will ensue providing the authority for the species is given, and the American entomologist does no violence either to good sense or propriety by designating the insect as it was first described, i. e., *Doryphora* 10-*lineata.* It is because of the present unsettled condition of entomological nomenclature that the custom yet prevails of attaching the abbreviated authority to the names of insects, as the only sure way to express our meaning and obviate all confusion as to the species intended.

THE BOGUS COLORADO POTATO-BEETLE.

(*Doryphora juncta,* Germar.)

It was at one time quite generally believed that the Colorado Potato-beetle had always existed in the lower Mississippi Valley, for the simple reason that a similar species, the Bogus Colorado Potato-beetle, (*Doryphora juncta,* Germar), was confounded with it. This species has existed in the South and Southwest, feeding upon the Horse-nettle, (*Solanum Carolinense*), a plant which is exceedingly abundant in some sections of the West. It has never yet been known to attack the cultivated potato, and in all likelihood never will do so, for as it has existed in the midst of the Potato for upwards of a century without ever having been known to attack the plant, it is not at all probable that it will do so at any future time.

This insect so closely resembles *Doryphora* 10-*lineata* that even a practiced entomologist would at first sight be apt to confound the two. It will, therefore, be worth while to briefly point out the minute, but invariable characteristics which distinguish them both in the larval and per-

[Fig. 37.]

Bogus Colorado Potato-beetle.—*a*, *a*, eggs; *b*, *b*, larvæ; *c*, beetle—natural size; *d*, left wing cover, showing punctation; *e*, leg—enlarged.

fect states. I first discovered the larva of *juncta*, and reared the beetle from it in 1864, at Columbus, Ky., and the accompanying figure from drawings then made will serve to illustrate the differences, when compared with Fig. 2, in the fore part of the work.

The eggs of 10-*lineata*, (Fig. 2, *a*, *a*), are of a translucent orange-red color, while those of *juncta*, (Fig. 37, *a*, *a*,), are whitish, with a faint tinge of flesh-color, and still more translucent. The newly hatched larvæ of the former are of a dark Venetian-red, and they become lighter as they grow older, while the newly hatched larvæ of the latter have the body as light as the full-grown individuals.*

In the full-grown larva of 10-*lineata*, (Fig. 2, *b*, *b*,),

* It is an interesting fact, that, as I have been able to ascertain by rearing *juncta* from the egg, its newly hatched larva instead of having the light yellow head and the single row of spots of the mature individuals, has a brown head and *two* rows of spots, the lower being less distinct than the upper row, and placed exactly in the same position as the lower row on the *mature* larvæ of 10-*lineata*. This is a very pretty exemplification of a very general law which has a significant evolutionary bearing, that all the species of a genus resemble each other more and more as we go back to the beginning of individual life.

the head is black, the first joint behind the head is pale and edged with black behind only; there is a double row of black spots along the side of the body, and the legs are black, the ground-color of the body being of a Venetian-red. In the full-grown larva of *juncta*, (Fig. 37 *b*), on the contrary, the head is of a pale color, the first joint behind the head reddish-brown and edged all round with black; there is but a single row of black spots along the side of the body, and the legs are pale, while the ground color of the body is of a pale cream, tinged with pink or flesh color. Such are the distinguishing characteristics of the two larvæ; but it is an interesting fact that these characters are not always constant, and that the larvæ of 10-*lineata*, especially when they feed upon the Horse-nettle, are sometimes almost as pale as *juncta*, and have the lower row of black spots more or less obsolete. The pupa of juncta is also the palest.

Now let us see what are the differences in the perfect beetle state of these two insects. Indeed, so minute are the differences, that in a drawing of the natural size, it is scarcely possible to exhibit them, but with the greatly enlarged leg and wing-case of each species, which are given in the foregoing figures, we shall readily be enabled to do so. Fig. 2, *d*, *d*, exhibits the true Colorado Potato-beetle; Fig. 37, *c*, the Bogus Colorado Potato-beetle, each of its natural size. Fig. 2. *e*, shows the *left* wing-case enlarged, and Fig. 2, *f*, an enlarged leg of the former; Fig. 37, *d*, the *left* wing-case enlarged, and Fig. 37, *e*, an enlarged leg of the latter. On a close inspection it will be perceived that in the former, (Fig. 2, *e*,), the boundary of each dark stripe on the wing-cases, especially toward the middle, is studded with confused and irregular punctations, partly inside and partly outside the edge of the dark stripe; that it is the third and fourth dark stripes, counting from the outside, that are united behind; and that in the leg both the knees and the feet are black. In

the latter, (Fig. 37, *d*), on the contrary, the dark stripes are accurately edged by a single regular row of punctations placed in a groove (*stria*); it is the second and third stripes—not the third and fourth—counting from the outside, that are united behind, the space between them being almost always brown; and the leg is entirely pale, except a black spot on the middle of the front of the thigh.

The spots on the thorax, in either of the above two species, are normally eighteen in number, arranged in the same very peculiar pattern which may be seen both in Fig. 2, *d*, *d́*, and in Fig. 37, *c*; and precisely the same variations in this complicated pattern occur in either species.

OTHER INSECT FOES OF THE POTATO.

We often see paragraphs in the papers, stating that "THE Potato Bug" has been very abundant and destructive in such a month and at such and such a place. Accompanying these statements, remarks are frequently added, that "THE Potato Bug" is preyed upon by such and such insects, so that we may soon expect to see it swept from off the face of the earth; and that, even if this desirable event should not take place, "THE Potato Bug" may be checked and controlled by such and such remedies.

Do the worthy men, who indite these notable paragraphs, ever consider for one moment, that there are over a dozen distinct insects preying upon the potato plant within the limits of the United States? That many of these species are confined within certain geographical limits? That the habits and history of several of them differ as widely as those of a hog and a horse? That some attack the potato both in the larva state and in the perfect or winged state; others in the perfect or winged state alone; and others again in the larva state alone? That in the case of eight of these insects there is but one single brood every year, while of the remaining three there are every year from two to three broods, each of them generated by females belonging to the preceding brood? That nine feed externally upon the leaves and more tender stems of the plant, while two of them burrow, like a borer, exclusively in the larger stalks? Finally, that almost every one of them has its peculiar insect enemies; and that a mode of attack, which will prove very successful against one, two, or three of them, will often turn out to be utterly worthless, when employed against the remainder?

It is true that at the present time the Colorado Potato-beetle has come to be very generally known by the above vague term, but the existence of the other species, which are also frequently dubbed by the same name, is a sufficient reason for greater explicitness. It will be a fitting conclusion to this little work to briefly indicate the habits and nature of the more destructive of the remaining insect foes of the Potato.

THE STALK-BORER (*Gortyna nitela*, Guen.)

[Ord. LEPIDOPTERA; Fam. APAMIDÆ.]

This larva (Fig. 38_2) is of a livid hue when young, with light stripes along the body, as shown in the figure.

[Fig. 38.]

1 2

GORTYNA NITELA.—Moth and immature larva.

When full-grown it generally becomes lighter, with the longitudinal lines broader, and at this time it more frequently resembles Fig. 39. It commonly burrows in the large stalks of the Potato; but is not peculiar to that plant, as it occurs also in the stalks of the Tomato, and in those of the Dahlia, Aster, Lily, Spirea, Salvia, and other garden flowers. I have likewise found it boring through the cob of growing Indian corn, and strangely confining itself to that portion of the ear: though it is likewise found occasionally in the stem of that plant; also in the soft stems of Milkweed, Castor bean, Rhubarb, *Chenopodium*,

[Fig. 39.]

GORTYNA NITELA.—Mature larva.

Eupatorium, and in the twigs of Peach and of Currant. By way of compensation, it is particularly partial to the stem of the common Cocklebur (*Xanthium strumarium*); and if it would only confine itself to such noxious weeds as this, it might be considered as a friend instead of an enemy.

Never having found this worm earlier than June or July, nor obtained the moth from the very earliest matured ones, until the latter part of August and fore part of September, the insect must necessarily be single-brooded, the egg requiring longer to hatch, and the larva longer to develop than of many other moths. Leaving the stalk in which they have burrowed the latter part of July, the worms descend a little below the surface of the ground and in three days become chrysalides. These are of the normal form, with two fine bristles at the extremity of the body, usually closed so as to form a point, but readily opened V-shaped at the will of the insect, as with hundreds of others of the same group. I have had the moth issue as early as the 30th of August, and as late as the 26th of September, and in one instance it emerged during a freezing night, being quite dull and numb at the time, thus showing beyond a doubt that the moths hybernate in a state of torpor, and then deposit their eggs, singly, on the plant destined for the worm, during the months of April and May. This moth (Fig. 38, 1) is of a mouse-gray color with the front wings finely sprinkled with Naples-yellow, and having a very faint lilac-colored hue; but distinguished mainly by an arcuated pale line running across their outer third.

Remedy—*Prevention.*—The careful florist, by an occasional close inspection of his plants about the beginning of July, may detect the point at which the borer entered, which is generally quite a distance from the ground, and can then cut it out without injury to the plant. As this is not feasible in a large potato field, care should be

taken to prevent its attacks another year as far as it is possible to do so, by hunting for it wherever a vine is seen to suddenly wilt.

THE POTATO STALK-WEEVIL (*Baridius trinotatus*, Say.)

[Ord. COLEOPTERA; Fam. CURCULIONIDÆ.]

This insect is more particularly a Southern species, occurring abundantly in the Middle States, but, according to Dr. Harris, being totally unknown in New England.* It is sometimes so abundant in S. Illinois, and Missouri, that potato-patches are utterly ruined by it, the vines appearing as if scalded. The beetle (Fig. 40 *c*) is of a bluish or ash-gray color, distinguished, as its name implies, by having three shiny black impressed spots at the lower edge of the thorax. The female deposits a single egg in an oblong slit about one-eighth inch long, which she has previously formed with her beak in the stalk of the potato. The larva subsequently hatches out, and bores into the heart of the stalk, always proceeding downwards towards the root. When full grown, it is a little over one-fourth inch long (Fig. 40, *a*), and is a soft whitish, legless grub, with a scaly head. Hence it can always be readily distinguished from the larva of the Stalk-borer, which has invariably sixteen legs, no matter how small it may be. Unlike this last insect, it becomes a pupa (Fig. 40, *b*) within the potato

[Fig. 40.]

POTATO STALK-WEEVIL.—*a*, larva; *b*, pupa; *c*, beetle —enlarged.

* This is evidently a mistake, as I have seen the species in Eastern collections, and Mr. E. M. Wilson of West Dummerston, Vt., wrote me, Aug. 26, 1870, that it was quite common in potato fields in Vermont, during that year.

stalk which it inhabits; and it comes out in the beetle state about the last of August or the beginning of September. The stalk inhabited by the larva almost always wilts and dies, and this wilting is first noticed in the latitude of St. Louis, about the first of July. So far as is at present known it attacks no other plant but the potato, and the perfect beetle, like many other snout-beetles, must of course live through the winter to reproduce its species in the following spring.

REMEDY.—Same as with the foregoing species. Burn all the vines which wilt from its attacks—roots and all, for it almost always works below ground. The Stalk-borer must be *searched* for, if one will be sure of killing it as it *leaves* the stalk to transform; but as this Stalk-weevil transforms within the vine, one may be pretty sure of destroying it by burning the vines when they first wilt.

THE POTATO OR TOMATO-WORM, (*Sphinx 5-maculata*, Haw.)

[Ord., LEPIDOPTERA; Fam., SPHINGIDÆ.]

This well known insect, the larva of which is herewith illustrated (Fig. 41, *A*), is usually called the Potato-worm, but it is far commoner on the closely allied tomato, the foliage of which it often clears off very completely in particular spots in a single night. Many persons are afraid to handle this worm, from an absurd idea that it has the power of stinging with the horn on its tail. But this is a vulgar error, and the worm is totally incapable of doing any direct harm to man, either with the conspicuous horn on its tail, or with any hidden weapon that it may have concealed about its person. In fact, this dreadful looking horn is not peculiar to the Potato-worm, but is met with in almost all the larvæ of the large and beautiful group to which it belongs. It seems to have no special use, but, like the bunch of hair on the breast of the turkey cock, to be a mere ornamental appendage.

When full-fed, which is usually about the last of Au-

[Fig. 41.]

POTATO OR TOMATO-WORM.—*A*, larva; *B*, pupa; *C*, moth.

gust, the Potato-worm burrows under ground and shortly afterwards transforms into the pupa state (Fig. 41, *B*). The pupa is often dug up in the spring from ground where tomatoes or potatoes were grown in the preceding season; and most persons that meet with it suppose that the singular, jug-handled appendage at one end of it is its *tail*. In reality, however, it is the *tongue-case*, and contains the long pliable tongue which the future moth will employ in lapping up the nectar of the flowers, before which, in the dusky gloom of some warm, balmy summer's evening, it hangs for a few moments suspended in the air, like the glorified ghost of some departed botanist.

The moth itself (Fig. 41, *C*) was formerly confounded with the Tobacco-worm moth (*Sphinx Carolina*, Linnæus), which indeed it very closely resembles, having the same series of orange colored spots on each side of the abdomen. The gray and black markings, however, of the wings differ perceptibly in the two species; and in the Tobacco-worm moth there is always a more or less faint white spot or dot near the centre of the front wing, which is never met with in the other species. My figure is somewhat darker than it should be. In Connecticut and other Northern States where tobacco is grown, the Potato-worm often feeds upon the leaves of the tobacco plant, the true Tobacco-worm being unknown in those latitudes. In the more southerly States, on the other hand, and in Mexico and in the West Indies, the true Potato-worm is unknown, and it is the Tobacco-worm that the tobacco growers have to fight; while in the intermediate country both species may frequently be captured on the wing in the same garden and upon the same evening. In other words, the Potato-worm is a northern species, the Tobacco-worm a southern species; but on the confines of the two districts exclusively inhabited by each, they intermingle in varying proportions, according to the latitude.

Remedies.—This insect is so large and conspicuous

that the most effectual mode of destroying it is by hand-picking. In destroying the worms in this manner care should be taken to leave alone all those specimens which one finds covered with little white oval cocoons, as these are the cocoons of little parasites* which materially assist us in its subjugation. The worm is also infested with a Tachina maggot, the young of a fly (*Exorista leucaniæ*), very much resembling *Lydella doryphora* (Fig. 29) in appearance and habit.

Blister-Beetles.

[Ord. Coleoptera; Fam. Meloidæ.]

Certain elongate beetles, having the same form and belonging to the same family as the Spanish-fly or Cantharis of commerce, have long been known to attack the Potato in different parts of the country, and the species become more numerous as we go West. These insects all agree in possessing vesicatory powers, and in their curious life-history. Harris and many other writers believed that their larvæ lived underground upon the roots of plants; but it is now fully established that they agree with many other members of the family, as, for instance, the oil-beetles (genus *Meloë*), in leading in their younger days a partly parasitic and partly predaceous life; and when this is remembered, the fact that some of the beetles have been observed to feed upon Doryphora larvæ, becomes less surprising. The female Blister-beetle is very prolific, her abdomen greatly swelling in pregnancy. She lays her eggs in masses in the ground and carefully covers them up. These hatch in a few days into minute, light-brown, bristly creatures with six long legs, two long bris-

* There are two distinct parasites which attack this worm, both species being very much of a size. One issues from the worm and spins a *smooth* white silken cocoon which it fastens by one end to the skin of the worm, and in due time produces a fly which Mr. Norton informs me is an undescribed species of *Blacus*, West. The other species forms an immense mass of loose woolly cocoons and produces an apparently undescribed species of *Microgaster*.

tles at the tail, and prominent jaws. They run about with great activity, mount different composite flowers frequented by bees, throw themselves on to the bodies of these whenever they get the chance, and by tenaciously clinging to their hirsute host, are carried into its nest. Here, as the female bee is about to lay an egg in the cell prepared for it, the blister-beetle larva drops into the cell. Floating for a while on the surface of the honey and feeding thereon, it molts a few times, each molt representing a loss of activity by reduction of the legs, until at last the active hexapod is changed into a clumsy legless maggot which fastens to the bee-larva that had meanwhile developed. In a short time this last is devoured, and then the blister-beetle larva goes through those curious transformations known as hypermetamorphoses—the larva transforming to the pupa within its old skin, and the beetle finally issuing therefrom. The Oil-beetle (*Meloë*) preys in this manner upon the common hive-bee, and aside from the injury done to the bee-brood, as just described, its larvæ when first hatched sometimes so crowd on and worry the mature bees, as to cause death. The Blister-beetles, however, so far as we now know, prey only on our wild, solitary bees, such as those belonging to the genera *Andrena* and *Halictus*.

With this brief glance at their precarious early life, I will give the reader a more particular acquaintance with the more common and destructive species.

[Fig. 42.]

STRIPED BLISTER-BEETLE.

THE STRIPED BLISTER-BEETLE.—This species (*Lytta vittata*, Fabr., Fig. 42), is almost exclusively a southern species, occurring in particular years very abundantly on the potato vine in Central and Southern Illinois, and in Missouri, though, according to Dr. Harris, it is also occasionally found even in New England. In some specimens, the broad outer black stripe on the wing-cases is di-

vided lengthways by a slender yellow line, so that instead of *two* there are *three* black stripes on each wing-case ; and in the same field all the intermediate grades between the two varieties may be met with ; thus proving that the four-striped individuals do not form a distinct species, as was formerly supposed by the European entomologist, Fabricius, but are mere varieties of the same species to which the six-striped individuals appertain It will occasionally feed on the Tomato, and prefers most kinds of potato tops to those of the Peach Blow.

THE ASH-GRAY BLISTER-BEETLE.—This species (*Lytta* cinerea*, Fabr., Fig 43, *a*, male), is the one commonly found in the more northerly parts of the Northern

[Fig. 43.]

Gray (*a*) and Black-rat (*b*) Blister-beet es, with the antennæ enlarged.

States, where it usually takes the place of the Striped species. It is of a uniform ash-gray color, but this color is given it by the presence upon its body of minute ash-gray scales or short hairs, and whenever these are rubbed

* In the male of this species, but not in the female, the first two joints of the antennæ are greatly elongated and dilated ; which is also the case with the species next to be referred to. Fig. 43 *d*, represents the male antennæ, above ; that of female below.) Hence, in splitting up the extensive and unwieldly old genus, (*Lytta*), these and certain allied species have been very properly placed in a genus by themselves, (*Macrobasis*), while the Striped Blister-beetle and the Margined Blister-beetle, not possessing this peculiarity, are grouped together under a distinct genus, (*Epicauta*). Practical men, however, who do not desire to trouble their heads with these niceties, will find it most convenient to class them all together under the old genus, (*Lytta*) ; and this we have accordingly done.

off, which happens almost as readily as on the wings of a butterfly, the original black color of its hide appears. It attacks not only potato vines, but also honey locusts, and especially the English or Windsor bean, and I have found it quite abundant on the Early Snap bean. It is very injurious to lucerne, also attacks the foliage of the apple-tree, and likewise gnaws into the young fruit.

THE BLACK-RAT BLISTER-BEETLE.—(*Lytta murina*, Lec., Fig. 43, *b*), sometimes swarms upon the Potato, especially in the more northern of the States.

THE BLACK BLISTER-BEETLE.—This species, (*Lytta atrata*, Fabr.), is very similar in appearance to the Black-rat Blister-beetle; the latter being distinguishable from it only by having four raised lines placed lengthwise upon each wing-case, and by the two first joints of the antennæ being greatly dilated and lengthened in the males, as shown at Fig, 43, *c*. The Black Blister-beetle appears in August and September, and is very common on the flowers of the Golden-rod. It sometimes does much injury to a potato-field, especially when the development of the tubers is retarded; but generally it appears too late in the season to prove very destructive.

THE MARGINED BLISTER-BEETLE.—This species (*Lytta marginata*, Fabr., Fig. 44), may be at once recognized by its general black color, and the narrow ash-gray edging to its wing-cases. It usually feeds on certain wild plants; but I found it quite abundant on potatoes, both in Missouri and in Illinois. It is a very common species in the Mississippi Valley, prefers most varieties of potato to the Peach-Blow, and congregates and feeds on many other plants, and especially the Kentucky Coffee tree, (*Gymnocladus Canadensis*). It also attacks the egg-plant.

[Fig. 44.]

MARGINED BLISTER-BEETLE.

Of the several other species, more peculiar to the West, the White Blister-beetle, (*Lytta albida*, Say), and the Spotted Blister-beetle, (*Lytta maculata*, Say), have proved very destructive to the Potato in Kansas.

REMEDIES.—The same remedies that apply to one apply to all of these Blister-beetles. They are rapid runners, and though abundantly able to fly, generally permit themselves to be driven on foot rather than use their wings. This is especially the case when they have been surfeiting on potato vines, so that a method of destruction in very general use is to drive them into windrows of straw and kill them by burning. They may also be caught in large quantities by a hand net, and killed, though not so effectually as Doryphora, by the Paris green mixture. If our pharmaceutists could once be induced to employ these native Cantharides instead of importing the foreign species, (for our own are every bit as good), farmers would find a double profit in collecting and killing these pests. As all of them appear rather late in the season, I would recommend the planting of early potatoes, which will be more likely to escape their attacks; also of the Peach Blow variety, the leaves of which seem to be more distasteful to them than those of any other sort.

THE THREE-LINED POTATO-BEETLE, (*Lema trilineata*, Oliv.)

[Ord. COLEOPTERA; Fam. CHRYSOMELIDÆ.]

The larva of the Three-lined Leaf-beetle may be distinguished from all other insects that prey upon the potato by its habit of covering itself with its own excrement. In Fig. 45, *a*, this larva is shown in profile, both full and half grown, covered with the soft greenish excrementitious matter which from time to time it discharges. Fig. 45, *c*, gives a somewhat magnified view of the pupa; and Fig. 45, *b*, shows the last few joints of the abdomen of the larva, magnified, and viewed, not in pro-

file, but from above. The vent of the larva, as will be seen from this last figure, is situated on the upper surface of the last joint, so that its excrement naturally falls upon its back, and by successive discharges is pushed forward towards its head, until the whole upper surface of the insect is covered with it. In other insects, which do not indulge in this singular practice, the vent is situated either at the extreme tip of the abdomen, or on its lower surface.

[Fig. 45.]

THREE-LINED POTATO-BEETLE.—*a*, *a*, larva; *b*, vent on anal joint; *c*, pupa; *d*, eggs.

There are several other larvæ, feeding upon other plants, which commonly wear cloaks of this strange material, among which may be mentioned one which is very common upon the Sumach, and which produces a jumping oval Leaf-beetle, (*Blepharida rhois*, Foerster), about a quarter of an inch long, and of yellow color, speckled with brick-red. The larva of certain Tortoise-beetles, (*Cassididæ*), some of which feed on the Morning Glory and the Sweet Potato vines, adopt the same practice, but in their case there is a forked process at the tail which curves over their back and receives the requisite supply of excrement.

Many authors have supposed that the object of the larva, in all these cases, is to protect its soft and tender body from the heat of the sun. This can scarcely be the correct explanation, because then they would throw away their parasols in cold cloudy weather, which they do not do. In all probability, the real aim of Nature, in the case of all these larvæ, is to defend them from the attacks of birds and of cannibal and parasitic insects.

There are two broods of this species every year. The first brood of larvæ may be found on the potato vine toward the latter end of June, and the second in August. The first brood stays underground about a fortnight before it emerges in the perfect beetle state ; and the second brood stays there all winter, and only emerges at the beginning of the following June. The perfect beetle, (Fig. 46), is of a pale yellow color, with three black stripes on its back, and bears a general resemblance to the common Cucumber-beetle, (*Diabrotica vittata*, Fabr., Fig. 47). From this last species, however, it may readily be distinguished by the remarkable pinching in of the sides of its thorax, so a to make quite a lady-like waist there, or what naturalists call a "constriction." It is also on the average a somewhat larger insect, and differs in other less obvious respects. As in the case of the Colorado Potato-beetle, the female, after coupling in the usual manner, lays her yellow eggs, (Fig. 45, *d*),on the under surface of the leaves of the potato plant. The larvæ hatching from these require about the same time to develop, and when full grown descend in the same manner into the ground, where they transform to pupæ, (Fig. 45, *c*), within a small oval chamber, from which in time the perfect beetle comes forth.

[Fig. 46.]

THREE-LINED POTATO-BEETLE.

[Fig. 47.]

CUCUMBER-BEETLE.

The Three-lined Leaf-beetle, in certain seasons, is a great pest in the Eastern States ; but it has never yet occurred in the Valley of the Mississippi in such numbers as to be particularly injurious.

REMEDIES.—Same as for Doryphora.

THE CUCUMBER FLEA-BEETLE, (*Haltica cucumeris*, Harris).

[Ord. COLEOPTERA, Fam. CHRYSOMELIDÆ].

This minute Beetle, (Fig. 48), belongs to the Flea-beetles, (*Halticidæ*), the same sub-group of the Leaf-beetles, (*Phytophaga*), to which also appertains the notorious Steel-blue Flea-beetle (*Haltica chalybea*, Illiger), that is such a pest to the vineyardist. Like all the rest of the flea-beetles, it has its hind thighs greatly enlarged, which enables it to jump with much agility. It is not peculiar to the Potato, but infests a great variety of plants, including the cucumber, from which it derives its name. It operates by eating minute round holes into the substance of the leaves which it attacks, but often not so as to penetrate entirely through it. In South Illinois whole fields of potatoes may often be observed looking seared and yellow, and with their leaves riddled with the round holes made by this insect. The larva feeds internally upon the substance of the leaf, like that of the closely allied European Flea-beetle of the turnip, (*Haltica nemorum*, Linn.); and, from its near relationship to that insect, we may infer that it goes underground to assume the pupa state, that it passes through all its stages in about a month, and that there are two or three broods in the course of the same season.

[Fig. 48.]

CUCUMBER FLEA-BEETLE.

REMEDIES.—Same as for Doryphora.

THE CLUBBED TORTOISE-BEETLE, (*Deloyala clavata*, Oliv.)

[Ord. COLEOPTERA; Fam. CASSIDIDÆ.]

This species which has been well described by one of my correspondents as "a scale-like, terrapin-shaped hard insect, spread out like a flying squirrel," that adhered tenaciously to the leaves of his potato plants, sometimes injuriously affects the Potato. By referring to Fig. 49 the reader will not be slow to learn why these beetles are

called Tortoise-beetles, for the patches of dark opaque color which extend on the thin, projecting, semi-transparent shell of that species, remind one very forcibly of the paws of a mud-turtle. The true legs however, which, as in all other insects, are six in number, and which in this species are so short that they scarcely reach beyond the thin shield-like crust that extends from the body, may readily be seen when the insect is turned upside down. This species has never been numerous enough to be considered much of a pest.

[Fig. 49.]

CLUBBED TORTOISE-BEETLE.

There are a few other species affecting the Potato, especially a small Dipterous worm that mines and blotches the first leaves of the young plants; but they are of minor importance, and the publishers admonish me that this little work has already grown to larger proportions than at first contemplated.

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